2-9040

RECOMMENDATIONS BY SPOC PHASE III SUBCOMMITTEE
TO
SPOC STEERING COMMITTEE
ON
PHASE III FEASIBILITY

SUBMITTED TO:

CANMET
DEPT. OF ENERGY, MINES AND RESOURCES
555 Booth Street
Ottawa, Ontario
K1A 0G1

TO FULFILL:

CANMET (DSS) Contract 23440/2/9040
UBC Account 64-8207

SUBMITTED BY:

A.L. Mular, Principal Investigator
University of British Columbia
Dept. of Mining and Mineral Process Engineering
Vancouver, B.C.
V6T 1W5

November 30, 1982

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INTRODUCTION

SPOC Objectives

The SPOC (Simulated Processing of Ore and Coal) project is a joint effort by the Canadian public and private sectors to transfer easily usable computer methodology for process evaluation, modelling, simulation and optimization.

For SPOC Phase I (1980-81), available methodology was consolidated in the form of manuals/computer programs as described in "Methodology Transfer For the Simulation of Mineral and Coal Processing Plants", Division Report 81-45; CANMET, Energy, Mines and Resources Canada, 1981 by D. Laguitton.

SPOC Phase II (1981-82) was initiated in 1981 and involves the transfer of SPOC Phase I documentation to Canadian coal/mineral operators by means of reports, workshops, summer student programs and model building projects. This phase is nearing completion (see "SPOC PROJECT: From Theory To Practice, 1981-82 Progress Report", Division Report 81-152, CANMET, Energy, Mines and Resources Canada, Dec. 1981, by D. Laguitton).

SPOC Phase III calls for industrial applications of SPOC technology to be initiated in 1983.

SPOC Steering Committee

The SPOC project is monitored by a steering committee that represents a cross section of the Canadian mineral industry. Current members are:

G. Agar	INCO
G. Brust	BC COAL
J. Campbell	DEVCO
A. Cormode	
K. Konigsman	NORANDA
D. Laguitton	CANMET
D. Madge	KILBORN
L. Pituley	GULF CAN RES

Decision To Form SPOC Phase III Subcommittee

In early 1982, the steering committee nominated a subcommittee to prepare detailed recommendations concerned with Phase III of SPOC. The committee was to be representative of engineering, operating companies and university investigators in Canada.

General Guidelines For SPOC Phase III Subcommittee

APPENDIX I describes the SPOC Phase III subcommittee objective, background of SPOC, general composition of the subcommittee and mode of operation as formulated by the steering committee. A final report must be submitted by November 30, 1982.

SPOC PHASE III SUBCOMMITTEE AND TERMS OF REFERENCE

Subcommittee Members

In May, 1982, the SPOC Phase III subcommittee, comprised of the following members, was formed:

K. R. Coyne	SNC
W. Dutton	Noranda
B. C. Flintoff	University of Alberta
C. A. Freitag	Kilborn Engineering
A. R. LaPlante	McGill University
A. L. Mular	University of B.C., Chairman
D. Laguitton	CANMET, Observer

The subcommittee held meetings on the following dates: June 1, 1982, August 11, 1982 and October 18, 1982.

Subcommittee Terms of Reference

Based on general guidelines, the subcommittee formulated a working plan that was approved by the SPOC steering committee on June 1, 1982. Details of the plan are shown on pages 3 and 4 of this report.

A. Off-Line Optimization Methodology

1. Review mineral plants that present the best potential for a successful application of off-line optimization methodology. The components of "best" are:

   (a) technical: the existing problem must be well within the range of the methodology

   (b) managerial: plant management must recognise the potential of the methodology and be willing to give it a chance with non-ambiguous support.

   (c) economical: the status of the economy prevailing in the mineral sector requires assessment of the cost to benefit ratio of the study and schemes to distribute costs.

   A company with an ideal application may be in economic difficulties that dictate no expenditures on the SPOC project. Access to data and plant measurements by outsiders with full return of the benefits to the plant can still present a viable route.

   (d) geographical: plant accessibility by a trans-Canadian group must be considered as well as the reputation of the plant involved.

2. Retain a maximum of two "best" sites in the mineral sector.

B. Coal Plant Sampling and Mass Balancing

1. Review Coal plants where Sampling/Mass Balancing present the best potential for generating data useful for models with items A-1-(a), A-1-(b), A-1-(c) and A-1-(d) in mind.

2. Select a maximum of two "best" sites in the Coal sector.

C. Model Development/Improvement

1. Propose various means to develop/improve on models of a cyclone classifier and a rod mill.

2. Select the best procedure to implement.

D. Analyse and describe the rationale behind a choice, describe the technical problem and its chances of being solved within two years.

1. Describe the data supply for the study:

(a) existing data

(b) Experimental design to acquire more data

2. Describe the milestones of the study in terms of tasks and realistic calendar

3. Quantify the required resources in terms of

(a) staff (scientific, technical, administrative)

(b) budget: breakdown of the costs
scenarios for financing (cost-sharing, Public vs. Private)

E. Determine whether management at proposed sites is willing to enter contract negotiations between December 1982 and April 1983 to materialise the above plans.

F. Submit a report of the study findings to the steering committee by November 30th, 1982.

The SPOC steering committee requested the subcommittee to make recommendations on the implementation of items A, B, C, D, and E, with less stress on item C.

POTENTIAL BEST SITES

To satisfy Item A, page 3, the subcommittee discussed "best" sites on a Canada-wide basis. Based upon the selection criteria, upon prior interest shown by some operators (see APPENDIX II) and upon prior informal contacts between operators and subcommittee members, the following mineral processing plants were identified for further investigation, particularly with respect to comminution circuits:

Heath Steele Mines Limited
Brenda Mines Limited
Equity Silver Mines Limited
Sherritt Gordon Mines Limited (Leaf Rapids mill)
Potash Corporation of Saskatchewan (Lanigan mill)
Kidd Creek Mines Limited
Gaspe Copper Mines Limited
INCO Limited (Thompson or Clarabelle mills)

After identifying the above operations, subcommittee members sought informal contact with corresponding on-site personnel. Answers to the following questions, apart from terms of reference requirements (items A.1(a) to A.1(d)), were solicited:

1. Will the plant be operating for the next several years?
2. What are the potential benefits to be gained?
   -existence of problems which could be solved by SPOC technology
   -improvement in circuit throughput or product size
   -energy or grinding medium savings
   -other
3. What resources would the mine contribute to the study?
   -existing data available
   -computer facilities available (data acquisition/off line capability)
   -competency of personnel/number available
   -good metallurgical laboratory
4. What are the characteristics of the circuit?
   -basic circuit/flowsheet
   -control and instrumentation (sensors, type loops, hardware)
   -general stability (flows, percent solids, cyclone pressure)
   -disturbances upstream/downstream
5. What are the characteristics of the feed?
   -variability (size, grade, hardness, type minerals)
   -heterogeneity (dense/light minerals, soft/hard minerals)

It should be noted that sites identified above are, in general, well regulated.

To satisfy Item B, page 3, the subcommittee completed a preliminary analysis of operating Canadian coal preparation plants. Plants expected to be in operation in 1983 were identified and ranked (see APPENDIX IV). Subject to the acquisition of further information concerning Items A.1(a) to A.1(d), the following were judged as potential sites for a coal sampling/material balancing demonstration:

B. C. Coal Limited
Fording Coal Limited

Referring to APPENDIX IV, note that Table 1 shows whether plants employ unit operations relevant to SPOC methodology (0 means the unit is not used; x means the unit is used). This knowledge is useful from a model building point of view.

RESULTS OF INFORMAL CONTACTS - OFF LINE OPTIMIZATION

The subcommittee, either by phone calls and/or by letters, made contact with on-site personnel. Results are summarized below.

Brenda Mines (contact by phone with Mr. C. Larsen)

Mr. Larsen's response was favorable, but he could not speak for management. Points of interest to SPOC are:

1. They expect to be operating for the next several years.
2. The ore is simple and of relatively uniform hardness.
3. The circuit is extremely well instrumented and under computer control.
4. Brenda has developed a crushing plant simulator, an improved grinding circuit simulator and a bulk flotation circuit simulator.
5. Brenda personnel are aware of all circuit disturbances.
6. A well-defined problem exists in the area of off-line optimization. The crushing circuit simulator could be connected to the grinding circuit simulator and the resulting "model" employed to find the best combination of operating variables that satisfy performance criteria.
7. The technical back-up is very good; the metallurgical lab is well trained.
8. The cost of a study might be relatively low.
9. Suitable constraints for equipment might have to be developed.

Brenda was shut down for a six week period. Personnel have no reason to expect further shutdowns, although there is no guarantee. In view of economic uncertainties, Brenda is not likely to contribute financially to a project; however, their contribution of a large data base and developed circuit simulators is expected to compensate.

Equity Silver Mines (contact by phone with Mr. I. Eljarbo)

Mr. Eljarbo's response was favorable, but he could not speak for management. Points of interest to SPOC are:

1. They expect to be operating for the next several years. They are one of the few mines who have not curtailed operation.
2. The ore is complex massive sulfides (variable and heterogeneous).
3. The circuit is instrumented and controlled by means of programmable digital controllers.
4. Equity has generated a model of their grinding circuit using their own simulator.
5. Students were employed this summer to improve on the simulator, so that a data base is available.
6. Disturbances have not been well-defined.
7. Technical back-up is good. A metallurgical lab is available.
8. Computing facilities are available.
9. A well-defined objective to evaluate alternative grinding circuits for a planned expansion and to improve the efficiency of the existing circuit exists. This appears to be within the range of SPOC technology.

Objectives of interest to Equity bear some resemblance to those listed by Sherritt Gordon Mines (see APPENDIX II). Mr. Eljarbo felt that Equity Mines Limited would contribute financially to a SPOC project at the mine.

Sherritt-Gordon Mines (contact by phone with W. A. Grell)

The Leaf Rapids mill was shut down (although it has recently started up at reduced capacity) at the time of contact with Mr. W. A. Grell. Mr. Grell's response was not optimistic at the time, and the following points are of interest to SPOC:

1. There was a great deal of uncertainty about future operation.
2. Management support is uncertain.
3. On-Site personnel have had no experience with SPOC-type methodology.
4. The ore is complex sulfides (variable and heterogeneous).
5. Disturbances are not defined and may be severe due to reduced underground mine production/development.

6. There are reasonably well-defined objectives (see APPENDIX II) amenable to SPOC methodology.
7. Grinding circuit instrumentation is minimal.
8. It is questionable whether the mine would contribute financially to a project
9. A data base useful to SPOC is not available most likely.

A computing facility is available on-site, which may be useful for data logging.

Potash Corporation of Saskatchewan (contact by phone with Mr. A. Richardson)

Mr. Richardson's response was favorable, but he felt that research budgets would be drastically reduced. They have already experienced financial cutbacks. The following points are of interest to SPOC:

1. The Lanigan mill start-up has been delayed to 1984. Other PCS plants have had production cutbacks.
2. Their objective would be to optimize flotation. A good model of PCS flotation is not available. Model building would have to accept the nature of the ore (cells mechanically degrade the soft KCl/NaCl minerals analogous to a comminution process).
3. There is a genuine interest in SPOC technology, but there are management shuffles associated with current politics.
4. Potash is an extremely important area for SPOC methodology. However, comminution circuits are best choices for SPOC at this time.
5. Ore from a given mine tends to be homogeneous and uniform.
6. Depending upon the mill, instrumentation is average to excellent.

Technical personnel are very interested in simulation, and are slowly developing a capability in this area. Any SPOC project would have to be relatively long term. Material balancing in the plant is a serious challenge, because fluids are saturated with salt (about 40% by weight). Thus, if temperatures fluctuate (as they do) salt minerals may dissolve or precipitate from solution. What goes in may not equal what comes out for solid phases!

The SPOC steering committee should look at the Potash industry as a potential site for their technology in the future.

Kidd Creek Mines (contact by letter and by phone)

Contact by letter with Ms. O. Matwijenko, Mr. R. Greer and Mr. W. Moore, and by phone resulted in positive responses. APPENDIX III shows relevant correspondence. Points of interest to SPOC are:

1. The plant is not expected to shut down over the next several years.
2. The ore is variable, complex and heterogeneous (half sulfide and half silicates).
3. Feed rate is variable; the circuit is well instrumented.
4. Disturbances are not excessive.
5. There is an existing data bank, but it is uncertain whether it is of value to SPOC methodology.
6. Computer facilities are available.
7. They have not developed a grinding circuit simulator to date.
8. They have several process engineers, although their knowledge of SPOC methodology may be limited at this time.
9. Their most important objective seems to be to determine whether cyclone underflow fed back to the rod mill will reduce the circulating load and thus minimize throughput losses. A secondary goal is to consider two stage grinding prior to flotation.

Since a primary objective is to consider recycle of cyclone underflow to the rod mill, a suitable rod mill model is required. Hence, it would be appropriate to consider a model building project, where the rod mill should be modelled by means of SPOC technology.

Gaspe Copper Mines Limited (contact by letter to Mr. G. Veillette)

As of August 11, 1982, a response had not been received. However, the following points arose during discussions among subcommittee members:

1. The plant is likely to be at reduced production or shut down.
2. Instrumentation is not good.
3. Operational stability is poor.

INCO Limited

It had been suggested that subcommittee members make contact with the following sites/on-site personnel:

Clarabelle Mill: Mr. Rudy Tenbergen - grinding circuit
Thompson Mill: Mr. Roy Perchyluk - grinding circuit
Copper Cliff: Dr. Kipkie - Cu/Ni matte flotation

Contact was successful at the Clarabelle mill only. However, Mr. Tenbergen indicated that technical problems would make a study excessively complicated.

Heath Steele Mines Limited

Heath Steele Mines was discussed as a possible site in further detail, and it was agreed that they should not be considered further due primarily to an uncertain future.

Subcommittee Decisions At August 11, 1982 Meeting

The subcommittee reached a consensus that the companies to be contacted further be limited to Brenda Mines, Equity Silver Mines and Kidd Creek Mines with the following approach:

1. By telephone discussion with the technical personnel on-site, the following would be established:

-objective
-extent of program required
-nature of manpower and other resource contribution by the company
-who should be contacted for a formal proposal and who should receive copies
-are they willing to work with others as sub-contractors or with universities

2. Prepare a proposal/cover letter which is derived from discussions with technical personnel on-site and from terms of reference. The proposal would be reviewed by on-site personnel. A final "rough draft" would then be written. Formal contact could then be made by the SPOC steering committee as desired.

3. Recommend "best" sites at the next formal subcommittee meeting on October 18, 1982.

RESULTS OF INFORMAL CONTACTS - COAL PLANT SAMPLING/MATERIAL BALANCING

Immediately following the August subcommittee meeting telephone contact was made with B. C. Coal (Mr. G. Brust) and Fording Coal (Mr. R. Voisey). Both indicated a preference for formal letter contact. Letters were prepared and transmitted in mid-August (see APPENDIX IV for example). The subcommittee contacted the operators in September for their decisions.

While B. C. Coal was interested in participating, Mr. Brust could envisage problems, stemming from current market conditions, which might preclude any work at that operation. At Fording Coal Limited, Mr. Voisey had resigned his position, so contact was made with Mr. R. Habinski. A letter was sent to him and within a week the subcommittee was informed that Fording did not wish to participate. These results were communicated to the subcommittee chairman and it was decided to contact the next two companies on the priority list, namely, DEVCO and LUSCAR STERCO. The subcommittee felt that these two plants were most immune to fluctuations in the coal markets and hence could make some commitment to a project.

Telephone contact was made with DEVCO** (Mr. J. C. Campbell) and with LUSCAR STERCO (Mr. M. Iliffe). Mr. Campbell voiced support on behalf of his company and was most cooperative. In the case of LUSCAR STERCO, a letter was requested and in subsequent discussions Mr. Iliffe felt that his company would seriously consider participation.

In view of the above interest, it was agreed that the subcommittee should proceed along the lines outlined on page 10 as quickly as possible.

** DEVCO had expressed an interest in participating in Phase III activities in the area of flotation modelling (see letter from J. C. Campbell, APPENDIX II). The subcommittee initially deemed such efforts to be a modelling study worthy of consideration under Item C, page 3.

It was the opinion of the subcommittee that both DEVCO and LUSCAR STERCO agreed in principle to the type of work which had been discussed informally. A main point of negotiation will relate to financing, specifically, to the cost-sharing arrangements and the total project budget (i.e., the extent of the work).

It should be stressed that coal can present some problems both in sampling (e.g., coarse particles) as well as in mass balancing (e.g., in-line degradation). These potential problems will help to ensure a thorough testing of SPOC methodology. In addition, they lend themselves to the development of special testing methods useful for future SPOC efforts.

RESULTS OF INFORMAL CONTACTS - MODEL DEVELOPMENT/IMPROVEMENT

At the August 11, 1982 meeting of the subcommittee, the whole subject of the nature, purpose and value of model development was debated at some length. APPENDIX V shows a rough draft recommendation that served as the basis for discussions. The subcommittee was unanimously in favor of such efforts being continued. Obviously, funding availability might be the problem.

A final decision on recommendations to the steering committee was postponed for the October 18th, 1982 meeting of the subcommittee.

FINAL RECOMMENDATIONS OF SPOC PHASE III SUBCOMMITTEE

In accord with the approach described on page 10, subcommittee members made contact with on-site personnel at Equity Silver Mines Limited, Brenda Mines, Kidd Creek Mines, DEVCO and LUSCAR STERCO LTD. It became apparent that some operators resent the paperwork associated with DSS contracts. They like the idea of being sub-contractors, where another organization such as a university, would handle the paperwork and participate at the same time. With this in mind, rough draft prop-

osals were prepared and transmitted "unofficially" to on-site personnel for further revision. At the time of writing, despite phone calls, official responses have not been received by subcommittee members. Both the mill metallurgist and mill superintendent at Equity and Kidd Creek are supportive. DEVCO and LUSCAR STERCO personnel respond favorably; Brenda Mines remains non-committal.

Rough draft proposals were reviewed critically by the subcommittee on October 18, 1982. Final recommendations by the subcommittee were as follows:

Recommendation I: A. That a university, such as UBC, act as contractor with CANMET to "develop a Grinding Circuit Simulator and Conduct off-line Optimization Studies" at Equity Silver Mines Limited. Equity Silver Mines would act as sub-contractor and contribute approximately 44% of the budget. An example "proposal" for submission to the Mine Manager at Equity is shown in APPENDIX VI, where UBC is the University and Prof. A.L. Mular is listed as the principal investigator.

B. That a university, such as UBC, act as contractor with CANMET to "Conduct off-line Optimization Studies" at Brenda Mines Limited. Brenda Mines would act as sub-contractor. An example "proposal" for submission to the Mine Manager at Brenda is shown in APPENDIX VII, where UBC is the University and Prof. A.L. Mular is listed as principal investigator.

The subcommittee concluded that Equity Mines and Brenda Mines should both be submitted to the Steering Committee as "best sites". However, Dr. A.R. LaPlante was requested to prepare a comparison between the two sites, based upon subcommittee discussions. His sub-reports are attached as APPENDIX VIII.

Recommendation II: That the sampling/material balancing project in the coal sector be conducted either at DEVCO's Victoria Junction coal preparation plant or at LUSCAR STERCO's Coal preparation plant under a suitable funding arrangement with CANMET. The operator should be involved to as great an extent as possible, such as by serving as contractor. An off-site body, for example--the Coal Research Centre, should co-operate in some way. In any case, the operator is expected to absorb a proportion of total costs.

The general character of example "proposals" is shown in APPENDIX IX. Note that secondary objectives to assess the extent of mechanical degradation of coarse coal and the merits of tracer tests are involved.

Recommendation III: That a university, such as McGill, act as a contractor with CANMET to develop a rod mill model at Kidd Creek Mines Limited. Kidd Creek would act as sub-contractor and contribute a portion of the budget. An example "proposal" for submission to Kidd Creek management is shown in APPENDIX X. Also attached is an evaluation of Kidd Creek (prepared by Dr. A.R. LaPlante at the request of the subcommittee) as a potential site for off-line studies versus modelling studies (see APPENDIX XI).

Recommendation IV: That CANMET circulate to industry/universities a request to bid on a proposal to develop a cyclone model based on new and existing cyclone data bases. Possible methods of operation are shown as Options 1, 2, and 4 of APPENDIX V.

Example Proposal Rationale

Each example proposal has been structured such that the following subject matter has been incorporated:

I. Technical Proposal
- Background
- Objectives
- General Approach
- Potential Problems
- Personnel
- Proprietary Information
- Sub-Contractor
- Consulting Investigators
- Planning/Sampling Team
- Time Schedule Estimate
- Project Control

II. Price Proposal
- Estimated Budget
- Cash flow chart
- Benefits

III. References

IV. Resumes of Project Personnel (where possible)

Note that each proposal (see APPENDICES VI, VII, IX and X) contains information appropriate to the terms of reference. Relative merits important to the Equity Mines, Brenda Mines and Kidd Creek Mines proposals are provided in APPENDICES VIII and XI.

SUBCOMMITTEE CONSENSUS

The subcommittee has been unanimous in its recommendations to the SPOC Steering Committee.

APPENDIX I

General Guidelines for SPOC Phase III Subcommittee

SUB-COMMITTEE FOR THE PREPARATION OF

PHASE 3 OF THE SPOC PROJECT

Objective: To complete a detailed investigation of the various alternatives open for the off-line plant optimization that will constitute phase 3 of the SPOC project. In particular to identify the most appropriate industrial sites for such a study, to expose the grounds for this choice (type of problem, company's plan to find a solution in 1983 and 1984), to outline the technical steps (experimental design, staff, budget, schedule) and to submit a report to the SPOC Steering Committee by November 30th, 1982.

Background: The SPOC project main objective is to transfer to industry easily usable computer methodology for process evaluation and optimization. It has been initiated in 1980 and will mature in 1986 after 3 successive phases of methodology consolidation, transfer and implementation called phases 1, 2 and 3 respectively. Although some activity in all phases is to continue during the entire project, the 3 phases can be divided chronologically: Phase 1, established the ground work for the SPOC manual and the SPOC software in 1980-1981,

Phase 2 is presently underway and aims at distributing manuals and software, organizing workshops and creating a Canadian support for the computer based methodology in the mineral and coal sectors,

Phase 3 to start in 1983 will be a test study aimed at making a clear case of the benefits of the SPOC methodology. It calls for direct application of the methods to an industrial problem in the mineral and coal sectors. From the results of phase 3 it is expected that a sufficient momentum will be gained in Canada for the self-continuation of the computer based research and development either within a national program or as private industrial initiatives.

More detailed about the SPOC project can be found in the yearly progress report available from CANMET, 552 Booth Street, Ottawa, Ontario K1A 0G1 (613) 996-7953.

Sub-committee Composition and Mode of Operation

The sub-committee is composed of a minimum of four and a maximum of six members appointed by the SPOC steering committee. A balance of regional, industrial and academic representation must be maintained.

The sub-committee operates under a contract with CANMET/DSS which covers the travel expenses related to the 3 meetings held in 1982 and expenses incurred in the drafting of the committee's report as defined and limited in the contract.

The sub-committee members must attend three meetings during the course of their mandate: Meeting one at the beginning of the contract and with the project steering committee, to discuss and finalize the sub-committee terms of reference and define a work plan.

Meeting two at mid-contract to review progress and prepare a progress report.

Meeting three at the end of the contract, to present findings and final report to the steering committee.

Between these meetings the sub-committee members will follow their own guidelines to canvas the possible industrial sites for phase 3.

SPOC

FIFTH STEERING COMMITTEE MEETING

AGENDA

EDMONTON, JUNE 1, 1982

LOCATION: Campus, University of Alberta (Subject to confirmation)

1. Minutes of Meeting No.4

2. Membership review

3. 1982 - 1983 Schedule

4. Meeting of the sub-committee for the preparation of phase 3 of the SPOC project

    a) review of terms of reference
    b) budget
    c) milestones

5. Other business

APPENDIX II

Letters Relevant to SPOC Phase III

Sent to

D. Laguitton

Copy for Sub-committee on Phase 3 21

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SHERRITT GORDON MINES LIMITED / MINING AND MILLING DIVISION
Leaf Rapids, Manitoba, Canada R0B 1W0 / Telex: 0766-8559 / Telephone: (204) 473-2415

February 2, 1982

D. Laguitton, Research Scientist
Mineral Dressing Section
Canmet
552 Booth St.
Ottawa, Ont.
K1A 0G1

Dear Daniel:

Re: Simulation of grinding circuit.

As requested in our recent telephone conversation, we can supply:-

Rod Mill discharge screen and density; dry tonnage; power

Ball Mill discharge screen and density; power

Cyclone overflow screen and density; volume (flowmeter)

Cyclone underflow screen and density

Cyclone feed volume and % solids (flow and density meters)

The screens run from 14 to 325 mesh. The densities were taken by hand and calculated by direct weighing of liquid and solid. The volumes and densities from the meters appear to be reasonable, but depend on accuracy of calibration.

These data are available for several dozen tests covering a range of power draught and tonnage for single-stage grinding.

Additionally, assays of metal and Insol in the screen fractions for one (series) two-stage grinding survey are also available.

The questions we would like to answer are:-

1. Is two stage ball mill operation more efficient then single stage operation (assuming a preliminary stage of rod mill grinding)?
2. Should the cyclones be operated at maximum underflow density (i.e., presumably, just short of roping), bearing in mind that cyclone feed density should not exceed, e.g., 70% solids?

3. What is the maximum (or optimum) circulating load?

4. For our ore, to obtain 70% -200

   What ball mill power is required?

   What circulating load, feed and underflow density will result?

   What cyclone parameters are required? (d_{50} sizes and/or cyclone diameter, vortex finder and spigot dimensions).

   What is shape of tromp curve(s)?

   (a) at 300 tons/hr. and (b) 160 tons/hr. (pebble grinding), when the cyclone overflow density is fixed at 35, 40% solids (S.G. ore 3.4, S.G. cyclone underflow about 3.8 - 4.0).

   The ball mills are 16½" diameter x 18' long, and use 1½" forged balls. Residence times in the ball mills were not measured.

If this is suitable to you, we can forward the data, and look forward to comparing with our results.

Wal Grell

W. A. Grell
Research Supervisor

WAG/rc

cc: C. Webber
M. Singh

Kidd Creek Mines Ltd.
B-2002, Timmins, Ontario P4N 7K1
Metallurgical Site (705) 235-8121

Copy for Sub-Committee on Phase 3

23

May 14, 1982

Dear Mr. Laguitton:

This is in response to your letter (Re: SPOC Phase II) dated April 14, 1982.

We are presently engaged in a series of sample surveys over one of the concentrator grinding circuits (see attached flow sheet). These surveys will be performed twice weekly over a 16 week period. In addition, we will be performing parallel laboratory grindability tests. Our primary interest is to determine the effect of grinding circuit variables on circuit throughput and on flotation feed size distribution. Ultimately, we would like to simulate grinding circuit performance.

Primary investigations will be as follows:

i) Is rod mill feed size distribution affected by fine ore bin levels?

ii) The affect of rod mill feed size distribution on circuit throughput.

iii) Is there any relationship between the feed assay and ore grindability?

iv) How variable is the performance of the circuit?

v) What is the effect of grindability on the distribution of sulphides in the flotation feed?

Your comments on our project and it's applicability to your program would be much appreciated.

Yours truly,

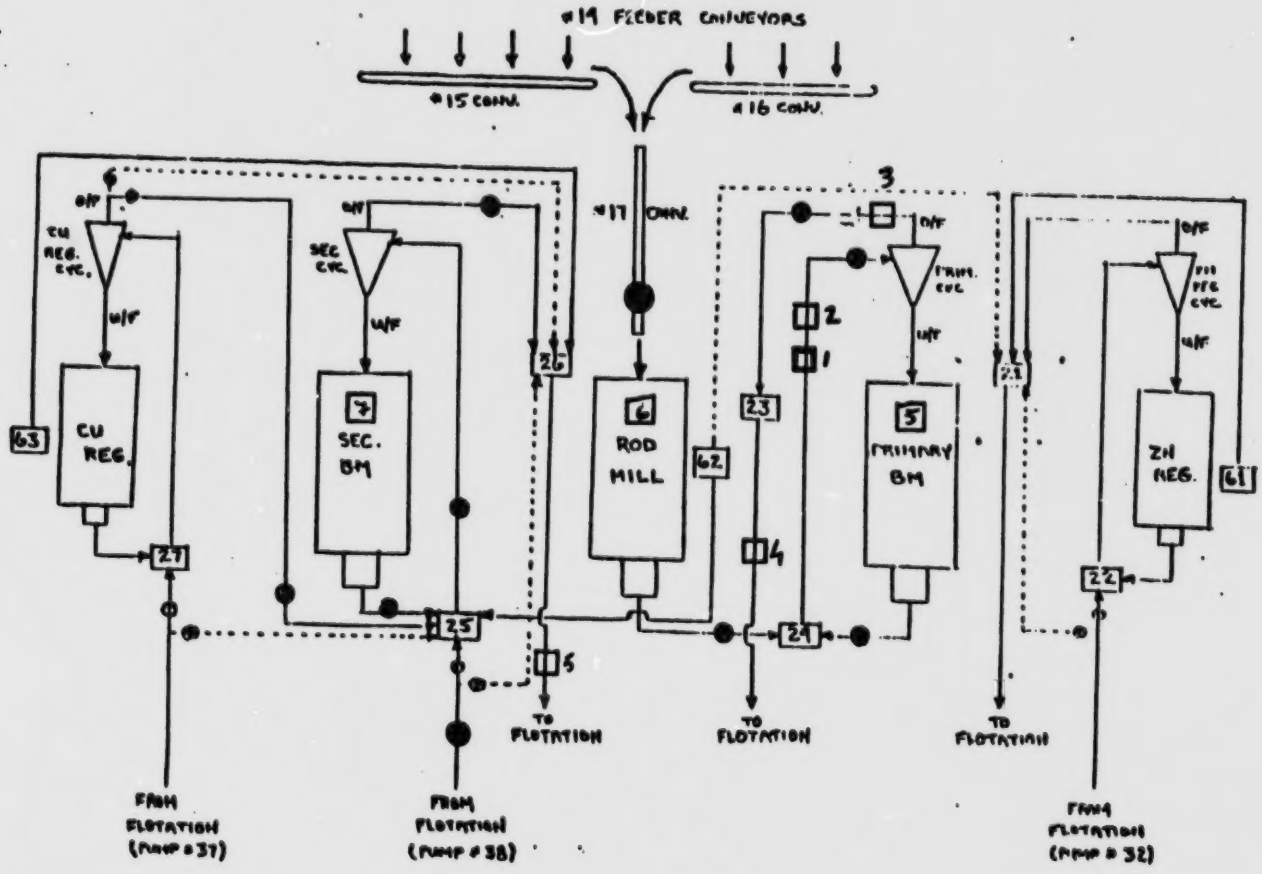
for O.M.

O. Matwijenko,
Senior Research and
Development Engineer

/dj/92/3.11
Attach.

A, B & C GRINDING FLOWSHEET

NOTE: AT 'C' GRINDING
1) SEC. & PRIM BM ARE IN REVERSE POSITIONS.
2) CU REG & ZN REG. CIRCUITS IN REVERSE POSITIONS.



● DENOTES SAMPLE POINT
[3] FLOWMETER
[2] DENSITY GAUGE
[3] PARTICLE SIZE MONITOR
[4] DENSITY GAUGE

[5] KILOWATT RECORDER
[6] "
[7] "

LEGEND
——▶ FEED FLOW
- - - - ▶ BY-PASSES
⊕ MANUAL VALVES

BY: R. ARMSTRONG

Copy for Sub-Committee on Phase

Fording
COAL LIMITED
P.O. Box 100, Elkford, British Columbia V0B 1H0/(604) 865-2271/Telex 041-45162

March 18th, 1982.

Canada Centre for Mineral
and Energy Technology,
555 Booth Street
Ottawa, Canada
K1A OG1.

Attention: Mr. Daniel Laguitton
Research Scientist.

Dear Daniel:

I am in receipt of your letter dated December 18, 1981 and would like to respond to your comments.

As you are aware, we have hired a full time process engineer who attended your course in Ottawa last summer. Andre Lazorenko will be working exclusively in the processing area with emphasis on the hardware and software aspects of our dryer and loadout computer system. As well, he will be studying process optimization of serveral wash plant circuits which will include mass balances and modelling.

It is our intention to maintain contact with you and as soon as our needs have been better identified, you will be contacted with regards to possibly setting up some contract work.

Should you have any questions please do not hesitate to contact me.

Yours truly,

Rick Habinski

R. L. Habinski
Senior Process Engineer.

c.c.: R. J. Voisey
Superintendent, Porcessing.

RLH:gem

Government of Canada
Cape Breton Development Corporation

Gouvernement du Canada
Société de développement du Cap-Breton

July 2, 1982

Dr. Daniel Laguitton
Research Scientist
Canmet
555 Booth Street
Ottawa, Ont.
K1A 0G1

Dear Daniel:

Re: SPOC Project

Confirming our telephone conversation of June 30.

After the SPOC committee meeting in Edmonton I contacted Mr. Clyburn, Manager of Coal Preparation for Cape Breton Development Corporation, in relation to the work planned by the SPOC III Subcommittee.

He has replied that we would be willing to cooperate and to offer the Victoria Junction Coal Preparation Plant as a demonstration plant. We are especially anxious to develop a model of the two coal flotation circuits to incorporate into the model of the V.J. plant developed in 1975 by the Nova Scotia Research Foundation.

We will make available our laboratory facilities and any other assistance required by the SPOC team to allow this development work to proceed.

Yours very truly,

J.C. Campbell, P.Eng.
Research Engineer

JCC:mlm

c.c. - Mr. Bruce Clyburn
Mr. A. Roy MacLean

P. O. Box 1330
Sydney, Nova Scotia
B1P 6K3
Telex 019-35214
Telephone 902-539-5910

C. P. 1330
Sydney, Nouvelle-Écosse
B1P 6K3
Telex 019-35214
Téléphone 902-539-5910

APPENDIX III

Documentation Relevant

to SPOC Phase III

Received From

Kidd Creek Mines

McGill University

Department of Mining & Metallurgical Engineering
Frank Dawson Adams Building Telephone (514) 392-5706 Telex 05-268-510

Sept. 3, 1982

Mr. Bill Moore
Mill Superintendent
Kidd Creek Mines Ltd.
B-2002, Timmins, Ontario
P4N 7K1

Dear Mr. Moore:

The SPOC project (Simulated Processing of Ore and Coal) is a joint effort of the Canadian public and private sectors. It aims at providing the Canadian mineral and coal industries with an easily usable computer package for process evaluation, process modelling, process design and processing teaching. In other words, the SPOC project was developed to facilitate the integration of computers as research and development tools in mineral and coal processing.

The project has gone through its first two phases since its inception in April 1980. Available methodology has been consolidated in phase one (1980-1981) by preparing chapters of an engineering manual describing all steps of a modelling study. Phase two (1981-1982) is devoted to methodology transfer through conferences, workshops, student programs and private discussions. Phase three (to start in 1982) calls for concrete implementation of the SPOC methodology in full scale applications with direct industrial participation. The objective of these applications is to demonstrate by concrete cases the benefits of computer aided process optimization and to trigger a cascade effect of numerous applications in the Canadian Mineral and Coal processing sectors during the subsequent years.

Your plant was retained by a CANMET sub-committee as one of three possible sites where the SPOC phase III can be implemented. The basis of this selection is described in the enclosed "Terms of Reference for the Sub-Committee on SPOC Phase 3." The program objective, as defined by Mr. Greer and Mr. Yoemans, would be to determine the potential of recycling part of the primary cyclone underflow to the rod mill feed to stabilize the primary circulating load and/or improve rod mill grinding efficiency.

con't...

Postal address: 3450 University Street, Montreal, PQ, Canada H3A 2A7

Mr. Greer has indicated that a commitment of 1.5 man-years by Kidd Creek would be acceptable, provided it is matched by an equivalent commitment by CANMET. It is reasonable to assume that Kidd Creek would also commit physical facilities, i.e. sampling, analytical and computer, to the project.

The contract would eventually be drafted after negotiations with CANMET and possibly a third party (e.g., consulting firm, university). These negotiations would begin in November 1982, after the final site has been chosen by the SPOC main steering committee.

As the sub-committee is scheduled to meet at the beginning of Oct. 1982 for further discussions, we would appreciate a response by the end of September.

Thank you in advance for your cooperation.

Yours sincerely,

André Laplante
Assistant Professor

AL/ab
cc: Mr. R. Greer
Mr. T. Yeomans
SPOC Committee members

SUMMARY OF THE SEPT. 3 CONVERSATION

The following points were discussed:

1. Length of the Project

   SPOC phase III has a planned duration of 2 years.

2. Nature of the CANMET/Kidd Creek Contributions

   Manpower: Dr. Laguitton mentioned that a 50/50 contribution would be agreeable to CANMET.
   (e.g. 1.5 person-years each)

   Others: Not specified, but I suspect that Kidd Creek would be the main contributor.

3. Nature of the Preliminary Committment

   The committment is a willingness to negociate with CANMET.

4. Extent of the Program Envisaged

   This can only be broadly defined. The following steps are suggested:

   - Literature survey of existing information/programs. Choice of models, variables to investigate (.1, .05).
   - Preliminary sampling campaign (Kidd Creek stall). Confirmation of the sampling adequacy (.2, .05).
   - Intensive summer sampling campaign. Determination

of the effect of recycling on the rod mill discharge (.7, 1.25).

- Data adjustment and fit of model parameters, verification of the model (.3, .1).
- Evaluation of the benefits of the flowsheet change (.2, .05).

The numbers in brackets are an estimate of the Kidd Creek and CANMET manpower requirements (man-year), respectively.

Kidd Creek Mines Ltd.
B-2002 Timmins, Ontario P4N 7K1
Metallurgical Site (705) 235-8121

September 30, 1982

Mr. A. Laplante
McGill University
Frank Dawson Adams Building
3450 University Street
Montreal, PQ H3A 2A7

Dear Mr. Laplante:

I am pleased to inform you that Kidd Creek Mines is willing to be put forth as a candidate for participation in Phase 3 of the SPOC program. We are looking forward to negotiating the terms of our participation in this project as previously outlined in your letter of September 3, 1982.

Yours sincerely,

G. W. Moore
Superintendent
Concentrator

kidd

Kidd Creek Mines Ltd.
B-2002, Timmins, Ontario P4N 7K1
Metallurgical Site (705) 235-8121

August 16, 1982

Mr. André Laplante
Assistant Professor
McGill University
3450 University Street,
Montreal, P.Q.
H3A 2A7

Dear Mr. Laplante

Please find enclosed some data on the milling of Kidd Creek ore as you requested in your letter dated July 2, 1982. Hopefully it will be adequate for your preliminary investigation.

If you wish to have more information , or if you have any questions on this information do not hesitate to call me or Associate Engineer Trevor Yoemans.

In the event of a mill test program, we could supply an engineer and a technician at least on a part-time basis.

Hoping this is satisfactory,

Ralph Greer

Ralph Greer
Senior Metallurgist

kln/rg
Encl.

kidd

MINERALOGY

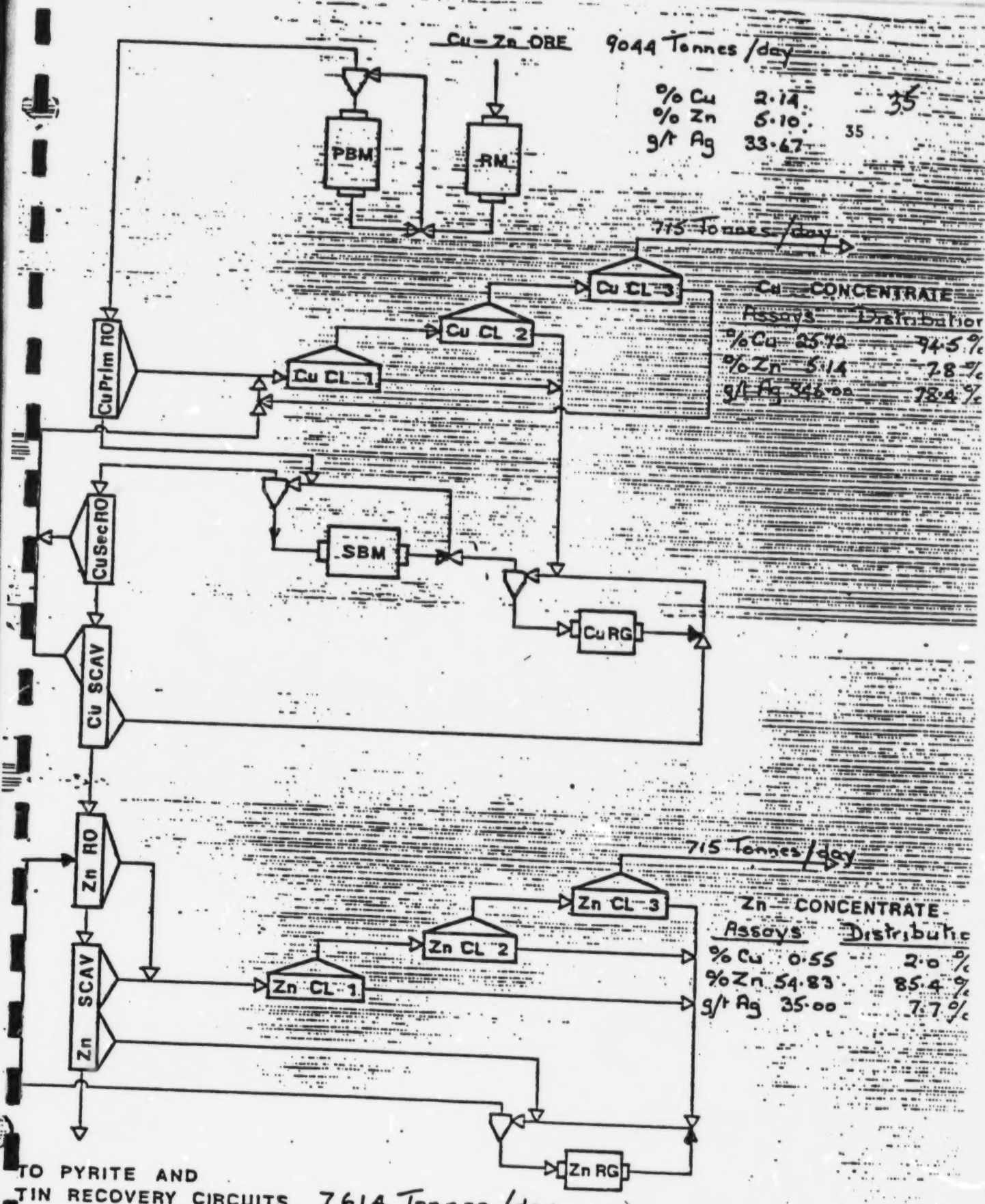
There are three major petrologic ore types. The first type, "stringer ore" is characterized by irregular, chalcopyrite stringers ramified through a siliceous, grey rhyolite host which is commonly recognizably volcaniclastic. Pyrite and/or pyrrhotite may be associated with the chalcopyrite stringers or may occur as associated, barren, stringer mineralization. The grade of this type of ore averages approximately 3 - 4 percent copper, with 0.1 - 1 percent sphalerite.

The second major ore type encompasses "massive, banded and bedded ores". This ore type is composed primarily of pyrite, chalcopyrite, sphalerite, galena and pyrrhotite. This type includes both homogeneous massive sulphides and complex sulphide mixtures. The grade of this type of ore runs approximately 6 percent zinc with small amounts of copper.

"Fragmental and breccia ore" constitutes the third major ore type. This ore type is quite hetrogeneous and is characterized by fragments of pyrite and/or sphalerite variably mixed with fragments of rhyolite, argillite, and chert. The grade of this type of ore is hard to quantify but typically is about 3 percent zinc with some silver.

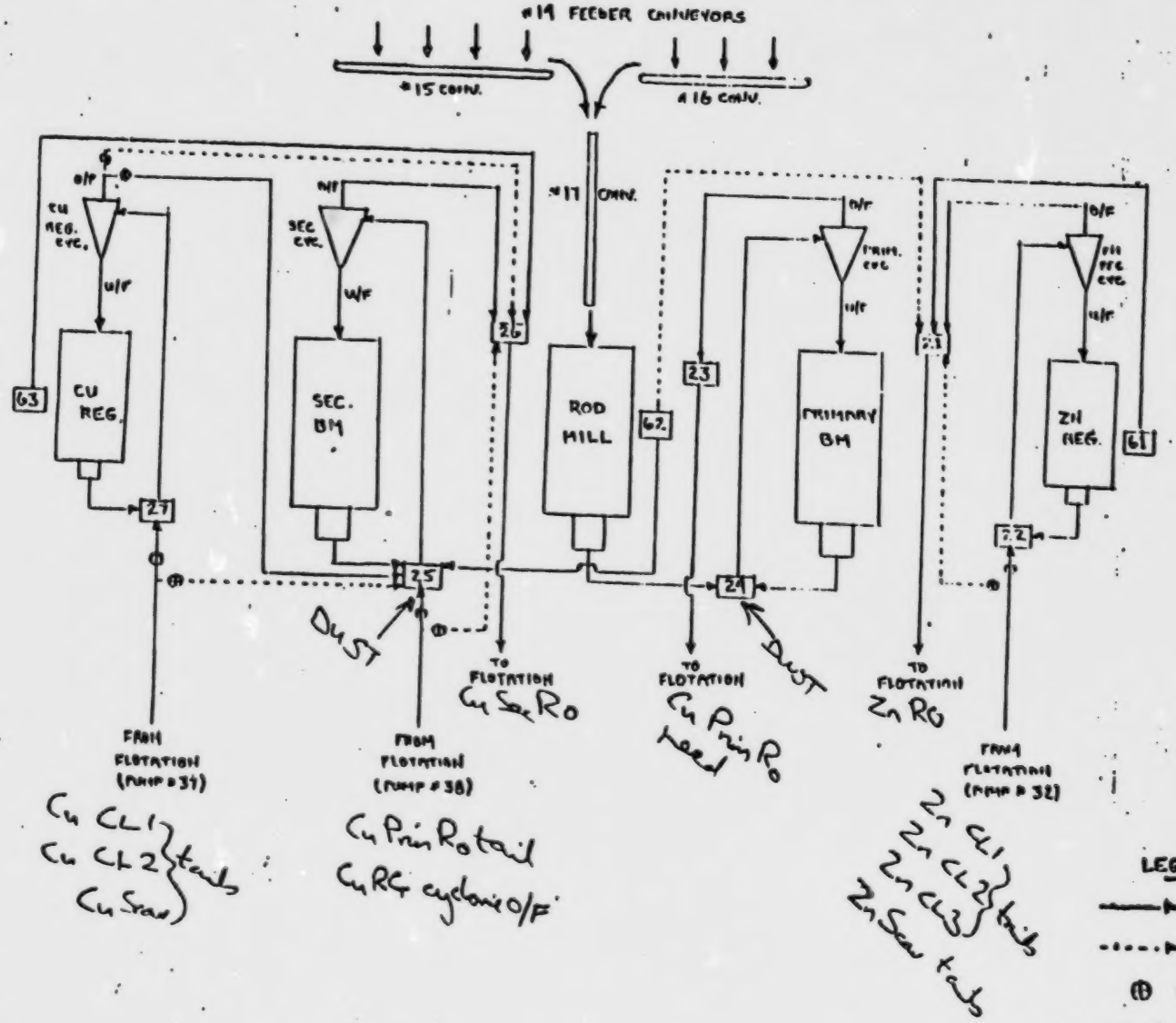
The major sulphide minerals include, pyrite, chalcopyrite, sphalerite, pyrrhotite, and galena with some marcasite. Minor sulphide minerals include bornite, chalcocite, digerite, and stannite.

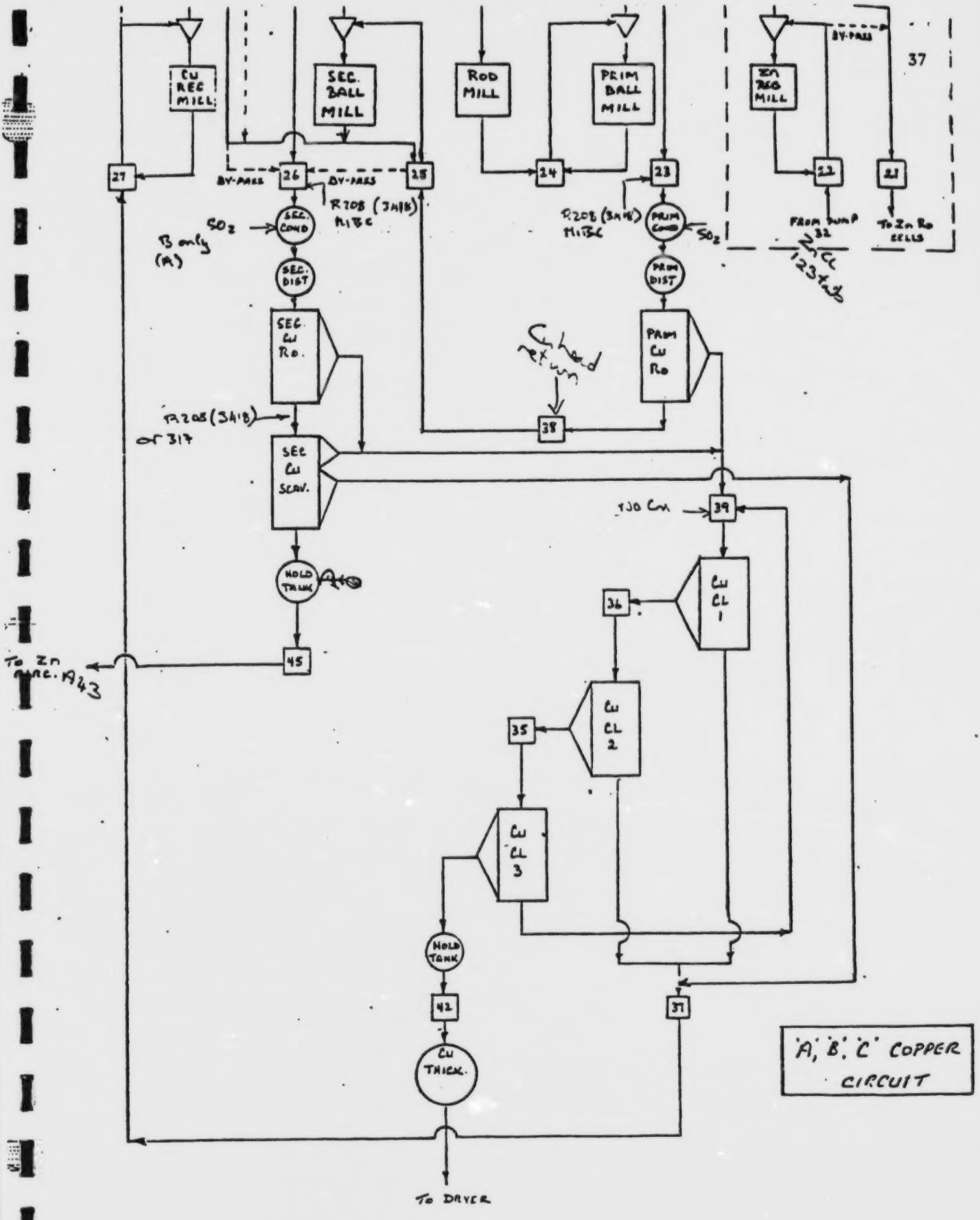
The major gangue minerals include quertz, sericite mica, talc, chlorite, dolomite-calcite and plagioclase feldspar.

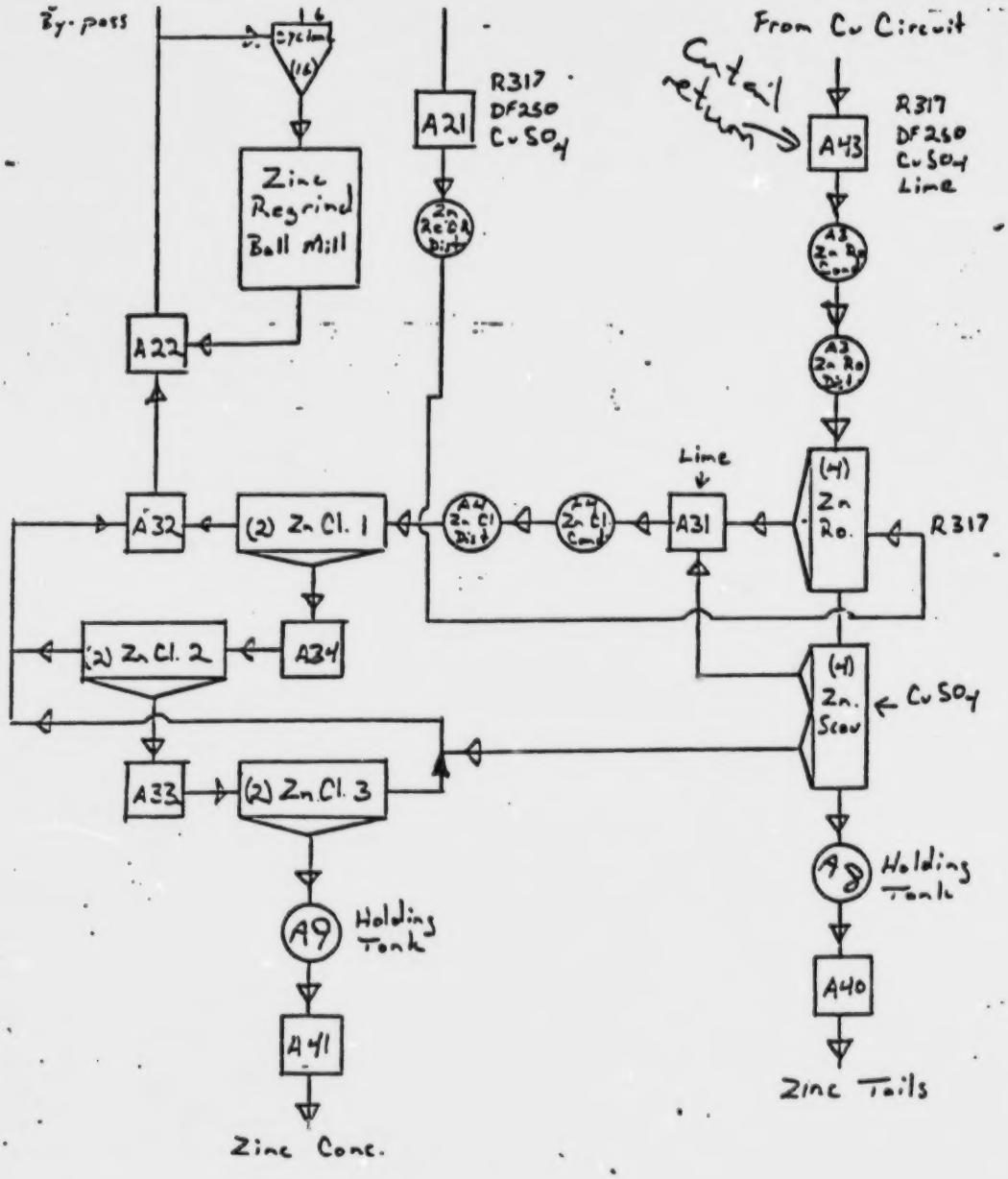

Cu–Zn ORE 9044 Tonnes/day
% Cu 2.14
% Zn 6.10
g/t Ag 33.67
PBM
RM
715 Tonnes/day
Cu CL 3
Cu CL 2
Cu CL 1
Cu Prim RO
Cu CONCENTRATE
Assays Distribution
% Cu 25.72 94.5 %
% Zn 5.14 2.8 %
g/t Ag 346.00 78.4 %
Cu Sec RO
SBM
Cu RG
Cu SCAV
Zn RO
715 Tonnes/day
Zn CL 3
Zn CL 2
Zn CL 1
Zn SCAV
Zn CONCENTRATE
Assays Distribution
% Cu 0.55 2.0 %
% Zn 54.83 85.4 %
g/t Ag 35.00 7.7 %
Zn RG
TO PYRITE AND
TIN RECOVERY CIRCUITS 7614 Tonnes/day
% Cu 0.09 % Pb 0.02 % Zn 0.43 g/t Ag 6.00 % Fe 12.0 % S 6.11 % Sn 0.06

A, B & C GRIND..G FLOWSHEET

NOTE: AT 'C' GRINDING
1) SEC. & PRIM BM ARE IN REVERSE POSITIONS.
2) CU REG & ZN REG. CIRCUITS IN REVERSE POSITIONS.




Cu REC MILL
SEC. BALL MILL
ROD MILL
PRIM BALL MILL
Zn REC MILL
BY-PASS
37
27
26
25
24
23
22
21
BY-PASS
BY-PASS
R208 (3418) MIBC
R208 (3418) MIBC
SEC. COND
PRIM COND
SO2
SO2
B only (A)
SEC. DIST
PRIM DIST
FROM DUMP 32
To Zn Rd CELLS
2nd Ck 123 Tank
SEC Cu Rd.
PRIM Cu Rd
Cu head return
38
R208 (3418) or 317
SEC Cu SCAV.
TO Cu
39
HOLD TANK
36
Cu CL 1
To Zn Rec. A43
45
35
Cu CL 2
Cu CL 3
HOLD TANK
42
37
Cu THICK.
TO DRYER
'A', 'B', 'C' COPPER CIRCUIT



A DIV. ZINC CIRCUIT

B & C Circuits are the same as A except there are 5 instead of 4 zinc roughing- scavenging lines.

INSTRUMENTATION AND CONTROL

Rod Mill

The feed rate is set at an indicator-controller. This feed rate is maintained by seven adjustable speed slot feeder conveyors, each powered by a DC motor via a motor-generator set.

The actual feed rate is measured by a Merrick type E weightometer, and recorded on a strip chart recorder, this signal is also returned to the indicator-controller system for closed loop control of tonnage feed rate.

A second signal is cascaded into the water/solid ratio control loop. Using this feed rate signal, the water addition to the mill is adjusted to maintain a certain percentage solids figure. The ratio is controllable for different load-grind situations, typically the percentage solids range from 80 to 84 percent. The water addition rate is measured by a magnetic flowmeter and displayed by a dial gauge.

The feed chutes are equipped with tilt probes, these being electrically interlocked with the feed belt, and an alarm system.

The mill is also equipped with temperature sensors on its trunnion bearings, and drive motor windings and bearings. The power drawn is indicated on a dial gauge and recorded on a strip recorder.

Primary Ball Mill And Primary Cyclones

The cyclone overflow pulp density is measured by an Accuracy gamma gauge. By comparison to a set point of between 51 and 54 percent solids, water addition to the cyclone feed pump is adjusted to maintain this set point density.

Water additions to the mill feed is controlled by manual adjustment of a set point, a magnetic flowmeter and dial gauge being used for measurement and display. Density control within the mill is achieved by manual sampling of the mill discharge with density can/Marcy balance. This leading to suitable adjustment to the water addition flow rate.

The mill is equipped with temperature sensors on its bearings and drive motor. Power drawn is indicated and recorded on a strip chart recorder.

An Autometrics P100 Particle Size Monitor is available for continuous size/density measurement. Also, a mass flow loop on the cyclone feed could be made operational for continuous circulating load ratio output, if linked to the rod mill feed rate.

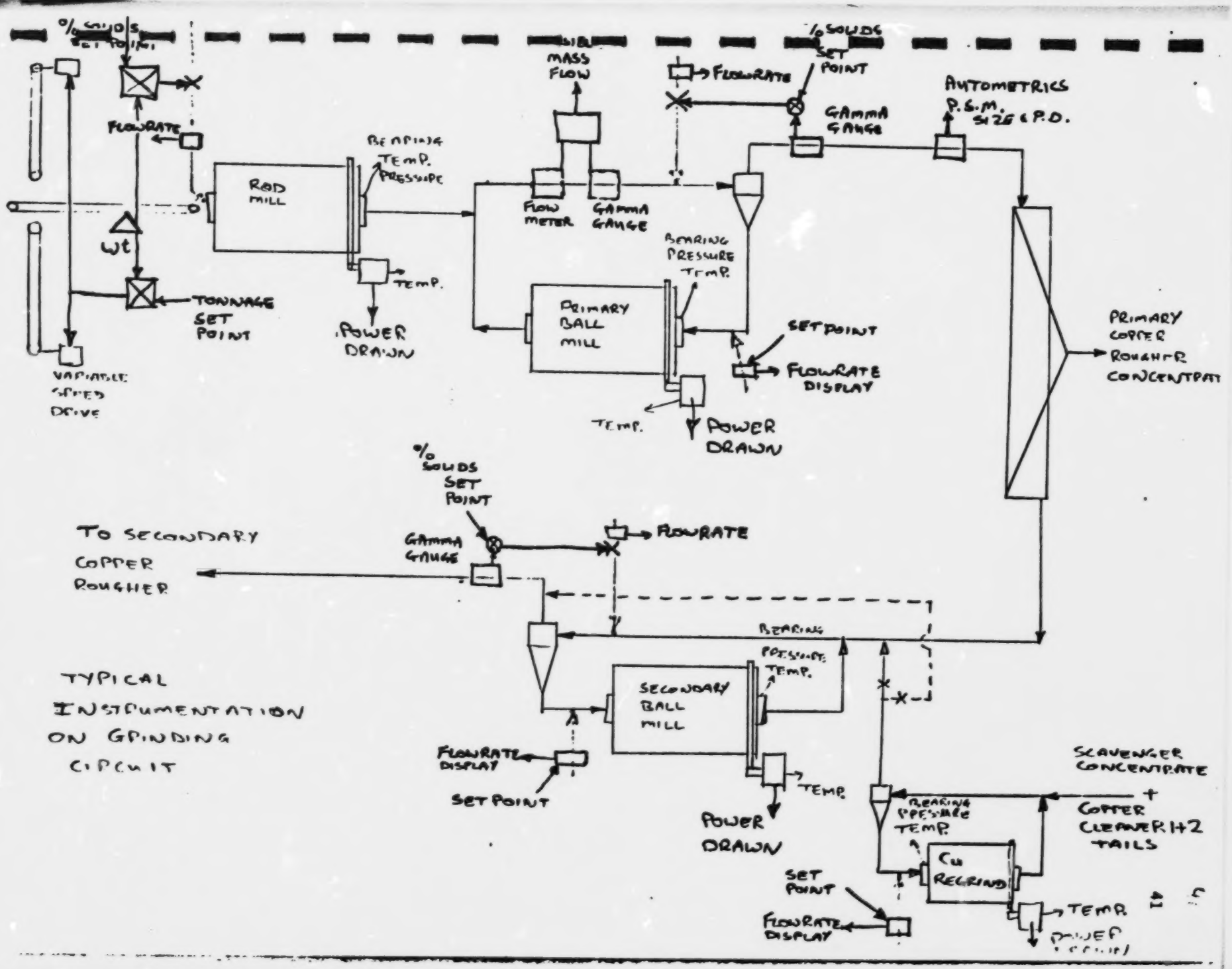
Secondary Ball Mill And Secondary Cyclones

The cyclone overflow pulp density is measured by an Accuracy gamma gauge. By comparison to a set point of between 30 and 45 percent solids, water addition to the cyclone feed pump is adjusted to maintain this set density.

Water addition to the mill is identical to the primary system, as is temperature sensing. However, power drawn is only indicated on a dial gauge, not continuously recorded.

Copper Regrind Ball Mill

The flow rate of water to the mill feed is measured by a magnetic flowmeter and displayed on a dial gauge. The density of the mill discharge being checked manually, and the water addition rate set point adjusted accordingly. The mill is equipped with temperature sensors on its bearings and drive motors. Power drawn is indicated on a dial gauge.



TYPICAL INSTRUMENTATION ON GRINDING CIRCUIT

EQUIPMENT SPECIFICATIONS

Rod Mill

16' long x 10'6" diameter - Canadian Allis Chalmers
Power: 1500 hp
4" rods - 15'6" long = 6,621 lbs.
Liners: slab and lifter bar Hi Cr steel/rubber

Primary Ball Mill

18' long x 12' diameter - Canadian Allis Chalmers
Power: 1500 hp
1-13/16" forged balls
Liners: rubber

Secondary Ball Mill

18' long x 12' diameter - Canadian Allis Chalmers
Power: 1500 hp
1-1/2" forged balls
Liners: rubber

Regrind Ball Mills

12' long x 8' diameter - Canadian Allis Chalmers
Power: 800 hp
1" forged balls
Liners: rubber

Primary Cyclones

Krebs 15" rubber lined
2-3/4" Apex, 3" Vortex Ceramic apexes·
8 of 5 - 6 running @ 17 - 20 psi

Secondary Cyclones

Krebs 10" rubber lined
1-1/2" Apex, 2-1/2" Vortex Ceramic apexes
15 of 9 - 11 running @ 17 - 20 psi

ROD MILL FEED MONTHLY COMPOSITES

	Pb %	Cu %	Zn %	Ag g/t	Fe %	S %	Sn %	Cd %	Insols %	Mg %	Ca %	SiO_2 %
ept/79	0.14	2.34	5.17	51.0	15.5	13.36	0.09	0.02	54.1	0.78	0.56	-
ct /79	0.16	1.48	5.24	60.0	20.9	10.3	0.09	0.03	58.5	1.26	0.62	54.6
Nov /79	0.14	2.27	4.57	50.0	12.2	9.63	0.12	0.02	63.1	1.30	0.52	-
Jan /80	0.07	2.23	4.32	40.0	12.7	9.81	0.08	0.02	57.3	1.45	0.81	54.5
eb /80	0.08	1.26	3.26	46.0	13.1	9.90	0.06	0.02	58.7	1.32	0.79	55.0
Mar /80	0.10	1.83	4.74	43.0	14.2	11.8	0.06	0.03	54.2	1.20	0.71	51.5
Apr /80	0.07	1.90	4.03	36.0	12.5	9.64	0.06	0.03	58.0	1.42	0.72	54.6
ay /80	0.09	2.00	4.33	41.0	13.7	10.09	0.07	0.02	60.2	1.27	0.63	-
une/80	0.09	2.02	4.11	35.0	15.1	9.99	0.12	0.02	58.6	1.40	0.76	-
July/80	0.02	2.01	4.44	42.0	13.0	9.94	0.07	0.01	56.8	0.42	0.19	-
ug /80	0.17	1.83	5.38	62.0	13.6	12.2	0.08	0.03	55.0	1.16	0.69	51.6
ept/80	0.11	2.30	5.16	43.0	14.1	12.0	0.07	0.03	55.1	1.10	0.48	49.2
Oct /80	0.16	1.96	5.85	50.0	15.9	14.2	0.07	0.03	49.6	1.03	0.62	47.0
Nov /80	0.14	2.10	6.10	58.0	15.3	13.4	0.06	0.03	50.4	1.15	0.69	46.9
ec /80	0.16	1.84	7.09	73.0	14.5	11.7	0.08	0.04	54.3	1.23	0.63	-
Jan /81	0.09	2.43	4.75	57.0	13.5	10.5	0.09	0.02	56.1	1.45	0.73	51.6
Aug /81	0.10	1.77	3.06	26.7	13.2	8.29	0.06	0.02	61.0	1.30	0.58	-
ay /82	-	1.60	8.95	34.3	14.2	12.80	0.05	0.01	51.1	1.20	0.30	-

CIRCUIT OPERATING DATA

Rod Mill Feed Grades

from weekly composites 1981 - 1982

Cu 1.71 - 3.07% Cu	Average 2.23% Cu
Zn 1.97 - 7.01% Zn	Average 4.49% Zn
Fe 12.0 - 14.1% Fe	Average 13.3% Fe

Typical Sizings

from weekly composites 1981 - 1982

Rod Mill feed:	26.8 - 43.1% + 1/2"	Average 36.2%	
Rod Mill discharge:	+ 65 mesh	62.9 - 72.4%	Average 66.6%
	-65 + 200 mesh	5.5 - 10.7%	Average 9.2%
	- 200 mesh	21.8 - 28.9%	Average 24.2%
Primary cyclone O/F:	+ 325 mesh	44 - 51%	Average 47%
Secondary cyclone O/F:	+ 325 mesh	17 - 28%	Average 23.5%

Typical percent solids

Rod Mill Discharge	82.5 - 87% solids
Primary Ball Mill Discharge	81 - 82% solids
Primary cyclone O/F	51 - 53% solids
Secondary Ball Mill Discharge	74 - 81% solids
Secondary cyclone O/F	30 - 36% solids

EXISTING DATA AVAILABLE ON GRINDING CIRCUIT

1. Eight recent sets of sizings around circuit. Samples taken include:

   i) Rod mill feed;
   ii) Rod mill discharge;
   iii) Primary cyclone feed;
   iv) Primary cyclone overflow;
   v) Primary ball mill feed;
   vi) Primary ball mill discharge;
   vii) Secondary cyclone feed;
   viii) Secondary cyclone overflow;
   ix) Secondary ball mill feed;
   x) Secondary ball mill discharge;

   From these sizings the following data has been produced:

   a) Reduction ratio's in rod, primary and secondary mills;
   b) Circulating loads in primary and secondary circuits;

   Also, the rod mill feed was tested for a form of grindability to enable a comparison between the different tests to be performed.

2. Plant weekly composites of grinding streams, streams and sizings taken include:

   i) Rod mill feed % $\pm$ 1/2"
   ii) Rod mill discharge % + 65 mesh, - 65 + 200, and - 200 mesh
   iii) Primary cyclone overflow % $\pm$ 325 mesh
   iv) Secondary cyclone overflow % $\pm$ 325 mesh

3. Reports on file on grinding circuit:

   a) 'B' Division Primary Grinding Survey (1967) - calculates primary circulating load ratio.

   b) 'A' Division Secondary Grinding Survey (1967) - with Cu regrind down, calculates circulating load ratio.

   c) Automatic Grinding Control - Progress Report (1975) - Operators Manual for the Automatic Grinding Control system on 'A' division (1975).

      An automatic grinding control system, using particle size, primary cyclone feed mass flow, and rod mill feed rate was tried. The aim being to control the particle size at a constant 51% - 325 mesh whilst optimizing throughput of the primary ball mill.

d) Methods of increasing grinding throughput (1979) - The aim being to reduce primary load and increase secondary load. Methods tried included;

   i) Primary cyclone manipulation, i.e. higher feed pulp density.

   ii) Media size in primary mill, i.e. larger ball size.

e) Numerous tests on standardizing/calibrating the P.S.M. for use with the above automatic grinding control system.

f) Report an effect of increased mill speed. The pinions on the rod mills, and primary ball mills, were changed to speed up the mills for increased throughput. The report details change in throughput and change in product size distribution.

g) Numerous reports on grab sizings of various product streams. Some for liberations - flotation studies, some for grinding studies.

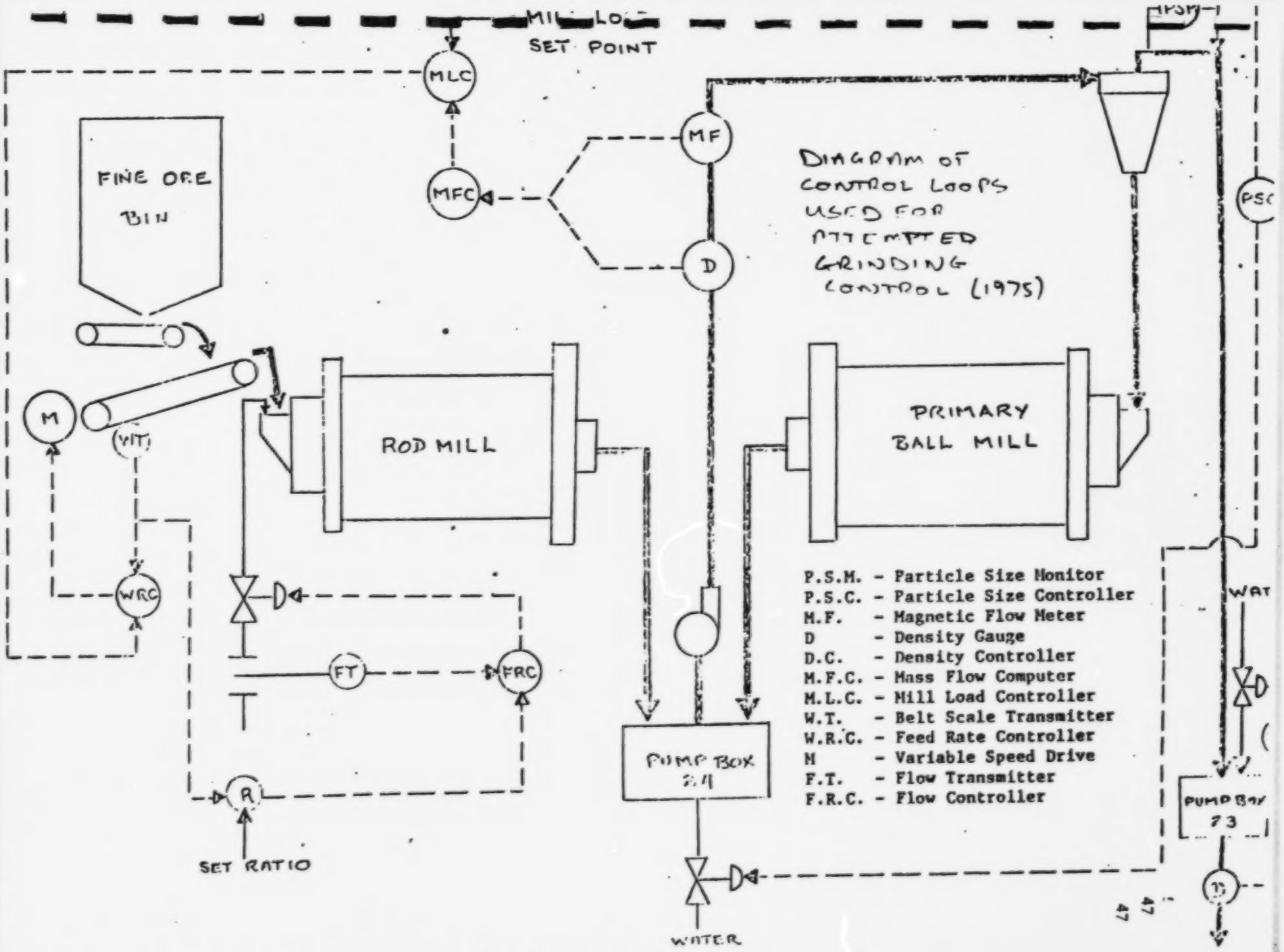

MILL LOAD SET POINT
MLC
MF
MFC
D
FINE ORE BIN
DIAGRAM OF CONTROL LOOPS USED FOR ATTEMPTED GRINDING CONTROL (1975)
M
WIT
ROD MILL
PRIMARY BALL MILL
WRC
FT
FRC
R
SET RATIO
PUMP BOX #1
PUMP BOX #3
WATER
WAT
P.S.M. - Particle Size Monitor
P.S.C. - Particle Size Controller
M.F. - Magnetic Flow Meter
D - Density Gauge
D.C. - Density Controller
M.F.C. - Mass Flow Computer
M.L.C. - Mill Load Controller
W.T. - Belt Scale Transmitter
W.R.C. - Feed Rate Controller
M - Variable Speed Drive
F.T. - Flow Transmitter
F.R.C. - Flow Controller

FIG 1

#/in		R.M.F	R.M.D	PRY CYC FD	PRY CYC O/F	PRY BMF	PRF BMD	SEC CYC F	SEC CYC O/F	SEC BMF	SEC BM
3/4	19155	10.47									
1/2	12770	20.51									
3/8	9577	12.66									
1/4	6385	11.81									
4	4699	6.22									
6	3327	606									
8	2362	5.02	8.28	4.97		4.09	3.21	0.27			
10	1651	3.72	10.24	3.68		4.21	2.32	0.12			
14	1168	2.98	10.83	3.94		6.95	2.75	0.10			
20	833	2.65	10.76	5.11		6.60	4.26	0.10			
28	580	1.99	7.85	5.35		6.14	5.18	0.15			
35	417	162	6.67	6.13		7.91	6.25	0.62			
48	295	1.97	6.38	8.74	4.61	10.68	8.32	1.56 27		2.99	1.35
65	208	1.36	6.36	8.36	5.31	9.56	10.15	3.55		6.65	3.61
100	147	0.85	3.46	8.11	6.57	8.92	9.18	5.75		9.00	6.15
150	104	1.02	3.45	8.79	8.35	9.51	10.05	9.68	2.23	12.70	11.32
200	74	1.06	3.27	8.18	9.82	8.23	9.32	12.57	3.18	12.78	14.96
270	53	0.91	2.63	5.50	8.12	4.61	5.86	13.28	5.55	13.25	15.77
-270	-53	7.12	(22.05)	(23.16)	(57.23)	(16.44)	(23.29)	(52.67)	(89.05)	(46.22)	(46.85)
	*.36		36.6 / 2.07	36.2 / 3.67	36.2 / 5.86	36.2 / 2.83	35.7 / 3.96	34.7 / 9.76	35.7 / 8.01	31.7 / 11.94	22.5 / 12.2
	*.27		26.9 / 2.60	26.6 / 3.29	26.7 / 7.64	26.6 / 2.25	26.7 / 3.65	26.7 / 13.75	26.7 / 12.27	22.7 / 18.31	23.7 / 14.3
	*.185		18.6 / 2.67	18.6 / 2.83	18.6 / 7.87	18.6 / 1.73	18.7 / 2.89	17.7 / 6.79	18.7 / 12.29	13.7 / 5.40	16.5 / 6.4
	*.125		12.7 / 2.34	12.6 / 2.61	12.7 / 5.95	12.6 / 1.36	12.5 / 2.67	11.7 / 6.72	12.4 / 10.86	10.7 / 1.95	11.7 / 3.1
	*.97		9.72 / 1.59	9.6 / 1.53	9.7 / 6.35	9.6 / 0.87	9.5 / 1.69	9.7 / 2.62	9.5 / 6.95	8.7 / 0.97	8.7 / 1.8
			-/10.97	-/9.64	-/26.78	-5.60	-9.06	-15.43	-38.63	-5.64	-10.3

TYPICALLY SIZING
AROUND GRINDING
CIRCUIT
TEST DATE MAY 13th 1982

COMPUTER FACILITIES

The major computer in the concentrator is a Modcomp II/25, having 128K bytes of memory, and three, 5M byte disk drives. The machine controls the two on-stream ARL x-ray analysers converting their output voltages to assays. The flotation control strategy is also operated through this machine, by monitoring of process variables (x-ray outputs). The addition rates of reagents and pulp levels are controlled. These operations are run continually, Material Balances and daily mill operation's reports are also run sporadically. Together the running time of these various tasks accounts for virtually all the total running time.

A Diogenis process control computer is used in a subserveance role to the Modcomp. The Diogenis monitors various harware control loops. It is linked to the Modcomp for the flotation control strategy, and controls through these hardware loops such things as level control, and reagent additions.

There are four DEC computers, a DEC System 2060, a DEC System 2020, a PDP 11/70 with 512 K bytes, and a PDP 11/45 with 256 K bytes. The PDP systems run programs such that the maximum size of any program block is 32 K bytes. The 2060 and 2020 are run on-line on a time share system. The major users of these being the warehouse inventory - withdrawal system, maintenance work planning, and purchasing. Other users are allocated time, dependant on the importance, size and length of the program to be run. Any program to be run on the DEC machines would need to be adapted to the DEC type of Fortran.

POTENTIAL PROGRAM BENEFITS

1. The high circulating loads in the primary circuit, causes material handling problems in that the pump sumps often register high levels. When this occurs, the rod mill feed rate is reduced until this overload reduces. In extreme cases of circuit overload, the rod mill feed will be stopped, and only restarted when the load is reduced to an acceptable level.

   The loss in throughput due to stopped mill feed is readily accountable and totals about 0.35% of total operating time. The loss due to reduced feed rate is difficult to account for, but could account for 2% of throughput.

   If these circulating loads could be balanced then the loss in production due to these overloads could perhaps be reduced.

2. Following from the above, there exists the possibility of putting a bleed from the primary cyclone underflow into the rod mill feed. If this could be done at these highloads, then the primary circulating load should be reduced more rapidly, thus enabling the loss in throughput to be minimized.

3. There exists the possibility of having a two stage grind prior to any flotation. This would have the effect of reducing production costs, due to the simplifications of the grinding - flotation circuit. Also, the control of the two grinding stages together would be simpler to automate, than two separate grind stages linked by a float.

***** KIDD CREEK MINES LTD. *****
** CONCENTRATOR COMPUTER SYSTEM **

14:15:44

MILLING OPERATIONS REPORT

(THURSDAY 8-JUL-82 INCLUSIVE)

DESCRIPTION	'A' DIVISION		'B' DIVISION		'C' DIVISION		'D' DIVISION		TOTAL	
	M-T-D	YEAR-TO-DATE	M-T-D	YEAR-TO-DATE	M-T-D	YEAR-TO-DATE	M-T-D	YEAR-TO-DATE	M-T-D	YEAR-TO-DATE
Tonnes Milled	25153.9	579892.3	26724.0	586471.7	26455.0	594632.4	24892.8	566850.2	103225.7	2327846.7
Rate/Operating Hour	139.1	132.0	139.9	131.6	138.1	133.0	65.1	126.5	436.6	523.1
Rate/Operating Day	3338.8	3169.1	3357.8	3158.2	3314.3	3191.2	1562.8	3036.3	10479.1	12554.0
Rate/Calendar Day	3144.2	3068.2	3340.5	3103.0	3306.9	3146.2	1555.8	2904.5	11347.4	12222.0
Scheduled Maint. - Hrs.	9.4	78.0	0.0	45.8	0.0	25.4	0.0	35.0	9.4	184.2
Routine Maint. - Hrs.	0.8	14.0	0.0	3.3	0.0	8.7	0.0	13.0	0.8	39.1
Lost Operating Hrs.	1.0	52.4	1.0	30.2	0.4	29.8	1.7	199.1	4.1	311.4
Total Lost Time	11.2	144.4	1.0	79.3	0.4	63.9	1.7	247.1	14.3	534.7
Actual Operating Hrs.	180.8	4391.6	191.0	4456.7	191.6	4472.1	382.3	4480.5	945.7	17800.9
Tot Schd Operating Hrs.	192.0	4536.0	192.0	4536.0	192.0	4536.0	384.0	4683.9	960.0	18291.8
Schd Non-Operating Hrs.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	0.0	43.8
Total Calendar Hrs.	192.0	4536.0	192.0	4536.0	192.0	4536.0	384.0	4727.7	960.0	18335.6
Operating Availability	94.17%	96.82%	99.48%	98.25%	99.78%	98.59%	99.55%	95.66%	98.25%	97.33%
Operating Time/Month	94.17%	96.82%	99.48%	98.25%	99.78%	98.59%	199.10%	98.78%	123.13%	98.11%
-- LOST TIME CAUSES ---										
Scheduled Maintenance	4.88%	1.72%	0.00%	1.01%	0.00%	0.56%	0.00%	0.74%	0.98%	1.00%
Liner Inspections	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Pump Failures	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Electrical Repairs	0.00%	0.07%	0.00%	0.02%	0.00%	0.03%	0.00%	0.03%	0.00%	0.04%
Mechanical Repairs	0.04%	0.21%	0.00%	0.05%	0.00%	0.15%	0.00%	0.20%	0.01%	0.15%
Liner Bolts	0.39%	0.03%	0.00%	0.00%	0.00%	0.01%	0.00%	0.04%	0.08%	0.02%
Charging Rod Mills	0.39%	0.31%	0.27%	0.27%	0.22%	0.29%	0.13%	0.29%	0.23%	0.29%
Power Failures	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Feed Chutes and Lines	0.00%	0.06%	0.14%	0.01%	0.00%	0.11%	0.00%	0.06%	0.03%	0.06%
Scheduled Non-Operating	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.. ..
Circuit Overload	0.13%	0.39%	0.10%	0.35%	0.00%	0.17%	0.33%	0.24%	0.18%	0.28%
Miscellaneous	0.00%	0.40%	0.00%	0.02%	0.00%	0.09%	0.00%	2.70%	0.00%	0.82%
Total Lost Time	5.83%	3.18%	0.52%	1.75%	0.22%	1.41%	0.45%	5.23%	1.49%	2.92%

APPENDIX IV

Letter Sent to B.C. Coal

and Identification of

Best Sites for Sampling/Balancing

of a Coal Plant

DEPARTMENT OF CHEMICAL ENGINEERING
THE UNIVERSITY OF ALBERTA
Edmonton • Alberta • Canada • T6G 2G6 • Telephone (403) 432-3337 • Telex 037-2979

Celebrating our 75th Anniversary

August 18th, 1982

Mr. G. Brust, Manager,
Preparation Plant,
B.C. Coal Ltd.,
Sparwood, B.C.

Dear Gil:

Re: SPOC-Phase III: Telecon of August 17th, 1982

I am writing on behalf of the SPOC-Phase III subcommittee to determine whether your plant would be willing to cooperate in the Planned Phase III activities, and if so, to what extent would you be willing to participate. You are already familiar with the overall goals of the SPOC project because of your role on the steering committee. However, I will take this opportunity to refresh your memory on the specific objectives of Phase III of the project.

The Phase III subcommittee has been asked by the parent steering committee of SPOC to define three projects which would demonstrate/test the technologies which arose from the first two phases of SPOC. Briefly, these projects are:

(1) To demonstrate the applicability of off-line optimization in a mineral processing concentrator.

(2) To demonstrate the applicability of the sampling/material balance methodology in a coal preparation plant.

(3) To review and suggest means of improving upon the mathematical models proposed for selected unit operations.

Of these, Carl Freitag of Kilborn Engineering (Toronto) and I have been asked to look after (2). On the basis of a preliminary assessment of Canadian coal preparation plants and, with the approval of the subcommittee as a whole, we have selected B.C. Coal Ltd. as one of two possible "best sites" to conduct the necessary testwork. Our immediate responsibility is to contact these companies and determine whether they are willing to participate. If so, the extent of this cooperation must be quantified, and a technical program loosely defined with a suggested budget including manpower requirements. This information will then be provided to the steering committee who will make the final plant selection in December of this year. All of the phase III activities are scheduled to begin in 1983. If you have any further questions in this area please do not hesitate to call Carl (416-252-5311) or me (403-432-3774)

With this background would you please respond to the questions I've listed below. If you prefer this can be done by telephone and I will write the appropriate letter of confirmation.

(1) Would your company be willing to provide access to your plant for the purpose of performing a steady state sampling campign with subsequent processing of the data by a material balance computer program?

This would require your close cooperation in providing sample access, maintenance of steady state operation, etc... Furthermore, the results of this work are intended for release into the public domain. In return, you will have the results of the study and would become more familiar with these aspects of the SPOC technology.

If the answer to (1) is yes, then:

(2) Would your organization prefer to contract directly to CANMET to perform this work, recognizing that the technology must be applied as documented in the SPOC manuals, at least as far as is practically possible?

(3) Would you permit an outside contractor to come on-site to perform this work? It would probably mean having them around for a period of < 2 weeks.

(4) If a contractor is selected to manage the project, would you prefer one which is jointly funded by government/industry (eg. Coal Mining Research Centre, CANMET - W.R.L. or University) or a private concern (eg. consultant)?

(5) To what extent would you be willing to support this work, specifically;

- direct financial participation.
- hire summer students who would be dedicated to the project during the on-site execution stage.
- provision of process engineering personnel from your group.
- other manpower assistance in conducting the sampling and/or subsequent analysis work.
- creation of new and necessary sampling points.
- installation of automated sampling equipment if required, at your capital expense.

(6) Finally, to what extent do you currently sample and calculate material balances.

I certainly appreciate your consideration of this letter. I am hopeful that we will get a positive response, at least to question (1).

Best regards,

Brian C. Flintoff, for
SPOC Phase III Subcommittee

BCF/mf

c.c. C. Freitag
A Mular

SPOC - PHASE III

REPORT ON SUB-COMMITTEE RECOMMENDATIONS

OBJECTIVE (B)

"SAMPLING AND MATERIAL BALANCE OF

A COAL PREPARATION PLANT"

THE IDENTIFICATION OF TWO BEST SITES

SUMMARY

A study of operating Canadian coal preparation plants was undertaken by the authors with a view to selecting the two best possible sites for conducting a demonstration of the SPOC methodologies for slurry/particulate sampling and material balance calculations. Inititally plants were rated on the basis of the evaluation criteria described later. The results of the preliminary work were tabled at the SPOC phase 1II subcommittee meeting in August and approved by this committee as a whole.

On the basis of this meeting B.C. Coal and Fording Coal Ltd. were selected and contact was made by telephone and letter soliciting their participation in the demonstration. Fording Coal subsequently decided not to get involved and B.C. Coal was only "lukewarm" to the idea because of the current uncertainties in the metallurgical coal market and the implications this might have. This information was tabled at the October meeting of the subcommittee and, in light of more recent developments in the marketplace the priority of approach was altered and Cape Breton Development Company and Luscar Sterco (1977) Ltd. were contacted. Both expressed an interest in participating in the demonstration.

To provide each of these companies with more detail on the demonstration a project outline complete with an example sampling campaign, budget and cost sharing scenario was prepared (copies attached). Both companies were generally receptive to the outline content recognizing that much of the detail must be negotiated in reaching a final contractual arrangement.

Implicit in the formulation of the outline was the assumption that no prior data was available for material balance calculations. In fact, the authors are aware that CANMET - W.R.L. sampled several Canadian Coal preparation plants with a view to calculating the material balances, however, this data is apparently accessible only through the individual companies. Since one of the purposes of this demonstration is to "shakedown" the documented SPOC techniques it is recommended that existing data bases be ignored in favour of a self consistent sampling/material balancing exercise.

In conclusion, the authors recommend to the SPOC Steering Committee that either DEVCO or Luscar Sterco be selected as the site for Phase III activity in the coal sector. Furthermore, it is recommended that a relatively complete sampling campaign be undertaken to expose both the strengths and weaknesses of the current methodologies. Careful attention must be given to developing reliable methods of "special-testing" in coal (eg independently estimating mass split through tracer studies.) The benefit to cost ratio for the successful demonstration is thought to be very high, in particular through the introduction of sate-of-the art technology to an industry which is just reemerging as a force in the international resource marketplace.

RESULTS OF PRELIMINARY ASSESSMENT STUDY

The material which follows briefly describes the method through which the various operating Canadian coal preparation plants were ranked for selection to participate in SPOC Phase III activities.

(1.0) EVALUATION CRITERIA

The evaluation criteria below represent the framework within which each coal preparation plant was assessed. In addition to the applicable criterion (in the terms of reference for this sub-committee), several other important considerations are defined.

(1) Plant management must recognize the potential of the methodology and be willing to give it a chance with non-ambiguous support.

(2) The operation should be "well run" with a clear knowledge of the plant flowsheet and a willingness to publish the results.

(3) The operation should have reasonably stable plant imput to minimize disturbances over the sampling interval.

(4) The plant should have acceptable sampling equipment in place and/or be prepared to provide access to the "necessary" sampling points.

(5) The plant should utilize most of the unit operations included in SPOC with a view of advancing the modelling work.

(6) Proximity to the contractors and the analytical facilities is important.

(2.0) OPERATING PLANTS

A Summary of the Canadian coal preparation plants

expected to be operational by January 1, 1983 is attached. It shows the location, approximate clean coal tonnage, unit operatin profile and maximum particle size in the plant feed (after breaking).

(3.0) ASSESSMENT

The plants are ranked in order of increasing appeal on the basis of the preliminary assessment. Only the most negative comments are included for justifying the rank.

Byron Creek	- too few unit ops., unique flowsheet.
Crows Nest Resources	- plants are too new and likely will still be in the mechanical debugging phase, light on unit ops.
McIntyre	- light on unit ops., little on-site technical support.
Cardinal River	- in the process of being sold, not enough on-site support.
Luscar Sterco	- potential political problems i.e reluctance to release data for reasons of competition.
DEVCO	- light on unit ops., geographically remote.

Fording	- supposedly an ill-understood flowsheet with frequent feed disturbances.
B.C. Coal	- very large plant by Canadian standards, perhaps on-site participation will be limited.

It is probably fair to say, at this time, that B.C. Coal and Fording Coal are recognized within the industry as having reasonably well run preparation plants. On this basis and with reason to believe that they would co-operate in the project, the recommendation is that one of these plants be chosen for the Phase III activity. If one, or both, of these operations declines the invitation then the next contact will be made by moving to next ranked position(s)

(4.0) FINAL COMMENT

It should be pointed out that, although it is easy to define the evaluation criteria, it is quite difficult, in most cases, to "measure" a particular plant because of unfamiliarity. A great deal of the evidence used in the assessment was distilled from conversations etc. (hearsay) which the authors have had with people connected to the industry.

TABLE 1.

A SUMMARY OF CANADIAN COAL PREPARATION PLANTS WHICH WILL BE OPERATING BY JANUARY 1, 1983

PLANT			WASHING PROCESSES					SIZING PROCESSES				COMMIN-UTION		
No.	Name/Location	Approx. Clean Coal Tonnage Per Year	Heavy Medium Baths	Heavy Medium Cyclones	Auto-Medium Cyclones	Froth Flotation	Jig	Coarse Screens (>3/8")	Desline Screens (~28M)	Fine Screens	Classifying Cyclones	Rotary Breckers	Crushers	Plant Feed Size
1	B.C. Coal Sparwood, B.C.	7.5×10^6	x	x	x	x	0	x	x	x	0	x	x	-4"
2	Fording Coal Elkford, B.C.	3×10^6	x	x	x	x	0	x	x	x	0	x	x	-6"
3	McIntyre Grande Cache, Alberta	2×10^6	0	x	0	x	0	0	x	0	0	x	0	-2"
4	Cardinal River Luscar Alberta	$\sim 2.2 \times 10^6$	0	x	x	x	0	x	x	0	x	x	x	-1 3/4"
5	Luscar Sterco Coal Valley, Alberta	2.6×10^6	x	x	x	0	0	x	x	0	x	x	x	-4"
6	Devco Sydney, N.S.	2.8×10^6	0	x	x	x	0	0	x	0	0	x	x	-2"
7	CNR-Thermal Line Creek,B.C.	1.4×10^6	x	0	0	0	0	x	0	0	0	x	0	-2"
8	CNR-Metallurgical Line Creek, B.C.	1.3×10^6	0	x	x	x	0	0	x	0	0	x	0	-2"
9	Byron Creek Corbin, B.C.	0.7×10^6	0	0	0	0	x	x	0	0	0	x	0	-4"

APPENDIX V

Rough Draft Recommendation

on Model Development/Improvement

Circulated to SPOC III Subcommittee

at August 11, 1982 Meeting

D R A F T 30 June 1982

SPOC PHASE 3

MODEL DEVELOPMENT/IMPROVEMENT

OBJECTIVE

To continue the model development/improvement which was started in SPOC phases 1 and 2 for the basic unit operations of a conventional grinding circuit, i.e. rod mill, ball mill and hydrocyclone.

BACKGROUND

Work has already been done under SPOC phase 2 in the development of a ball mill model using a relatively large number of industrial data sets. While the model is expected to be accurate and useful within the range of data used to develop it, these data are for similar ore and similar mills. To make such a model more generally useful, additional data from a variety of mills with different ores are required. Some of these data may already be available, but of indifferent quality. To insure that the correct and adequate data, of acceptable quality, are collected, it would appear to be advisable that a data collection team approach be used to collect the data during a series of sampling campaigns around a grinding circuit.

APPROACH

OPTION 1

A sampling team, including one member with mill experience, would organize and execute a series of sampling campaigns around, at least, 3 different grinding circuits, in close cooperation with the local mill personnel.

The actual sampling could be done 2 or 3 times per day, to obtain 10-20 data sets in 5 to 8 days. Except for slurry density measurements, which would be done immediately, all screening, assays, etc. would be done by local plant personnel after the sampling team had left. Balancing of the data would be done by one member of the sampling team with a demonstration of the technique on their own data, to be done at each mill.

OPTION 2

Metallurgists from each of 3 or 4 mills to be sampled would form the sampling team, coordinated by someone with experience using BILMAT and with modelling. After a preliminary briefing session, this sampling team would visit each mill in turn to perform the sampling campaigns, as in Option 1. Balancing of data would be done as in Option 1.

OPTION 3

A workshop of 3-5 days would be given to metallurgists from the 3 or 4 mills to be sampled, covering the details of sample collection, preparation and data treatment. These metallurgists would then return to their own mills to do or supervise the sampling campaigns required, with the cooperation and assistance of a coordinator who is familiar with the BILMAT program and the data requirements for modelling. The balancing of data would be done as in Option 1.

APPLIES IN EVERY CASE ANYWAY

The determination of the breakage function of a sample of ore from each of the mills must also be done, preferably all under the control of one investigator who can insure that the methods used are identical from sample to sample.

OPTION 4

The sampling team of Option 1 might be made up of students who were hired and trained by CANMET, but supervised by someone with mill experience.

POSSIBLE LOCATIONS

1. Noranda Mines, Matagami Division
2. Mattabi Mines
3. Brunswick Mining (LOWSTABLE CKT)
4. Noranda Mines, Geco Division
5. KIDD CREEK
6. SHERRITT GORDON
7. GASPÉ COPPER

RECOMMENDATIONS

The recommended approach would be Option 2, although this is probably the least likely to occur. The second choice would be Option 1.

APPENDIX VI

Example Proposal to

Develop a Grinding Circuit Simulator

and

Conduct Off-Line Optimization Studies

RESEARCH PROPOSAL*

TO:

DEVELOP A GRINDING CIRCUIT SIMULATOR

AND

CONDUCT OFF-LINE OPTIMIZATION STUDIES

PREPARED BY:

A. L. Mular
Professor of Mineral Process Engineering
University of British Columbia
Department of Mining and Mineral Process Engineering
Vancouver, B. C.

SUBMITTED TO:

CANMET (SPOC PROJECT)
553 Booth Street
Ottawa, Ontario

November 12, 1982

*EXAMPLE PROPOSAL ONLY. FOR SUBMISSION TO
SPOC STEERING COMMITTEE

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	Item I: A. L. Mular	
	Item II: Ivan Eljarbo	
	Item III: C. R. Larsen	
	Item IV: B. C. Flintoff	
	Item V: A. R. LaPlante	
	Item VI: D. Hodouin	
	Item VII: Research Engineer	
	Item VIII: Research Assistant	
	Item IX: Computer Programmer	
	Item X: Summer Student	
	Item XI: Technician	

I. TECHNICAL PROPOSAL

A. Background

In April, 1980, CANMET initiated a Canada-wide project (1), entitled Simulated Processing of Ore and Coal (SPOC), to provide the mining industry with current computer methodology for process evaluation and optimization. SPOC techniques have been documented (1), so that mineral processing circuits can be simulated in production environments. The use of simulators for off-line optimization (2,3,4,5) appears now to be within the realm of practicability and ready for plant trials.

Equity Silver Mines Limited, a Placer Development Limited subsidiary located near Houston, B. C., is projecting an expansion of their grinding circuit. Research to increase the efficiency of the existing circuit has been initiated. Consequently, if a simulator of the Equity grinding circuit is developed with up-to-date SPOC methodology, off-line optimization studies can be conducted for the existing circuit. Alternate circuit configurations, including the expanded circuit, can be studied with the computer. Predictions from the study can be verified after the expanded circuit has been installed and in operation. Hence, computer predictions are thereby amenable to comparison----a realistic test of SPOC methodology is thus possible.

B. Objective

The objective of this study is to develop a simulator of the Equity Mines Limited grinding circuit, which will be employed (1) to optimize the efficiency of the existing circuit, (2) to compare the performance of alternative expanded circuit configurations based on a "best efficiency/lowest cost" criterion, (3) to estimate a "best" size of cyclone classifier (on paper) and "best" configuration (i.e., single stage/double stage or other alternatives) of classifiers in an existing and an expanded circuit, (4) to assist in the selection of grinding circuit control systems and (5) to document this study, in detail, for use by other Placer Development Limited operations.

C. General Approach

The University of British Columbia will assume contract responsibility for the overall project, with Professor A. L. Mular as principal investigator. Equity Silver Mines Limited will serve as a sub-contractor, with Mr. Ivan Eljarbo, senior metallurgist, as on-site team leader. Project consultant will be C. R. Larsen, Brenda Mines Limited. Professors B. C. Flintoff, A. R. LaPlante and D. Hodouin will serve as consulting investigators.

Using SPOC methodology and any necessary additional techniques to be suitably documented and explained, the project will be conducted in a series of sequential tasks as follows:

Task 1 (State of the art review and familiarization): Project personnel will review SPOC documentation, SPOC computer programs, general simulation procedures, data acquisition methodology and define existing grinding circuit parameters. Meetings will be held and a "current status" report prepared. Existing grinding circuit data acquired by Equity Silver Mines personnel will be evaluated and possibly utilized in conjunction with Task 2.

Task 2 (Acquisition of grinding circuit data for modelling): A planning/sampling team will acquire data around the existing grinding circuit in accord with SPOC methodology. Based on SPOC documentation, necessary computer programs will be written/modified for use in the Equity Mines computer and the UBC computer. The computing facilities at CANMET will serve as back-up.

Task 3 (Model building): Mathematical models of process units will be constructed by means of SPOC techniques. If alternate methods are necessary, these must be documented and explained.

Task 4 (Construction of simulator): A small executive structure will be developed to permit study of existing and expanded circuits. The executive should be small enough to mount in the Equity computer.

However, the program must be of a size to accomodate for any possible expanded circuits envisaged.

Task 5 (Testing the simulator): The simulator will be tested against the existing circuit to confirm validity.

Task 6 (Efficiency of existing circuit): Efficiency criteria will be adopted and employed for the existing circuit. Of importance are increases in rod mill reduction ratios, increases in cyclone classifier efficiencies and increases in throughputs at specified grinds. Simulated circuit conditions that indicate highest efficiencies will be evaluated.

Task 7 (Performance of alternative circuits): The performance "on paper" of various circuit configurations, including the expanded circuit, will be studied. The simulator will recommend the best size of cyclones, their number and their corresponding configuration.

Task 8 (Comparison with expanded circuit): The actual performance of the expanded circuit will be compared with the simulated version. The expanded circuit should be operational within the next year and a half.

Task 9 (Control strategy evaluations): The simulator will be employed to assist in the evaluation of grinding circuit control strategies. Results of evaluations will be documented.

Task 10 (Final project report): Results of all tasks will be documented in sufficient detail to serve as a SPOC manual and for use by Placer Development Limited operations. The University of British Columbia has responsibility for all report preparation submitted to CANMET, with approval by Equity Silver Mines prior to release.

Student theses which arise from this project may serve as reports to CANMET, with prior approval by Equity.

D. Potential Problems

Problems are expected when building a rod mill model useful for design, although a rod mill design model may not be critical. Empiricism may be necessary for the rod mill and cyclone models. Ore complexity may be a problem which must be considered at the data acquisition stage.

E. Personnel (See APPENDICES for resumes)

1. A. L. Mular, Professor, University of B. C., Principal Investigator.
2. Ivan Eljarbo, Senior Metallurgist, Equity Silver Mines Ltd, On-Site Team Leader.
3. C. R. Larsen, Senior Engineer, Brenda Mines Ltd., Consultant
4. A. R. LaPlante, Ass't. Professor, McGill University, Consulting Investigator.
5. D. Hodouin, Ass't. Professor, University of Laval, Consulting Investigator.
6. B. C. Flintoff, Ass't. Professor, University of Alberta, Consulting Investigator.
7. Research Engineer, University of B. C., full time.
8. Research Assistant, University of B. C., full time.
9. Computer Programmer, University of B. C., part time.
10. Summer Student, Equity Silver Mines Ltd., part time.
11. Technician, Equity Silver Mines Ltd., part time.

F. Proprietary Information

Raw data acquired at Equity Mines Limited for model building will be released to SPOC. Results will be published by SPOC and will be available to Placer Development Limited. Graduate student theses at UBC that are involved with the project will be published, either by SPOC or in the normal manner.

G. Sub-Contractor

Equity Silver Mines Limited agrees to:

(1) Release grinding circuit data currently available for model building to the project.

(2) Appoint Mr. Ivan Eljarbo as on-site team leader responsible for on-site activities associated with Tasks 1 to 10.

(3) Make the Equity Mines grinding circuit available to the project for data acquisition, model building and simulation.

(4) Utilize one technician, part-time, to serve on the sampling team and for associated laboratory measurements.

(5) Employ one summer student for data acquisition purposes and laboratory work.

(6) Make the Equity Mines laboratory available for measurements associated with sampling and model verification.

H. Consultant/Consulting Investigators

(a) Mr. C. R. Larsen, Brenda Mines Ltd., agrees to serve as a consultant on circuit sampling, cyclone model building, executive structure development and expanded circuit design. One week of his time/year is needed.

(b) Professors B. C. Flintoff, A. R. LaPlante and D. Hodouin agree to serve as consulting investigators on the project (each 1 week/year).

I. Planning Team/Sampling Team

The planning committee will consist of Dr. D. Laguitton, CANMET, as an Observer, Prof. A. L. Mular, Principal Investigator, Mr. Ivan Eljarbo, On-Site Team Leader, a UBC research engineer, a senior operator at Equity Silver Mines, the consultant and the consulting investigators.

The sampling team will consist of Mr. Ivan Eljarbo, Team Leader, a UBC research engineer, a UBC research assistant, an Equity Mines summer student and an Equity Mines technician. Prof. A. L. Mular will assist Mr. Eljarbo during portions of the sampling campaign. Assistance from the consultant and consulting investigators may be required.

The UBC computer programmer may be called upon to assist in the conversion of programs to be mounted in the Equity computer. The bulk of the computing effort is expected to reside at UBC.

The mineral processing lab at UBC will be available to the project as required. Certain measurements may be difficult to obtain at Equity Mines.

J. Time Schedule

An estimated time schedule to complete tasks is as follows:

Task	Estimated Time To Completion
1	January 1, 1983 to April 30, 1983
2	May 1, 1983 to August 31, 1983
3	September 1, 1983 to February 28, 1984
4	March 1, 1984 to April 39, 1984
5	May 1, 1984 to August 31, 1984
6	September 1, 1984 to October 31, 1984
7	November 1, 1984 to December 31, 1984
8	January 1, 1985 to February 28, 1985
9	March 1, 1985 to April 30, 1985
10	May 1, 1985 to June 30, 1985

The tasks will overlap to some extent, so that times are estimates only. Total time to completion will be 2½ years.

K. Project Control

Technical/Accounting control of the project will be provided by the University of British Columbia with Professor A. L. Mular as Principal Investigator. Progress reports will be submitted every two months on behalf of all participants by Professor A. L. Mular.

Accounting will be done by the University of B. C., Department of Finance, based on invoices from sub-contractors/consultant/consulting investigators. Invoices for progress payments will be submitted monthly.

II. PRICE PROPOSAL

This project will be funded jointly by CANMET and by Equity Silver Mines Limited. Two budgets will be necessary; one for UBC and paid by by CANMET. The other will be for Equity Silver Mines and paid by Equity.

A small sum in the UBC budget will be allocated to Equity Silver Mines to cover travel costs and expenses during planning/report meetings.

A. UBC Budget (Funded by CANMET)

	Year 1	Year 2	Year ½
1. Salaries:			
Principal Investigator	4,000.	4,500.	2,250.
Research Engineer	34,000.	37,400.	21,000.
Research Assistant	10,500.	11,500.	6,200.
Programmer (part-time)	7,000.	8,000.	4,000.
2. Supplies/Expenses/living accomodation at Equity	8,000.	8,000.	4,000.
3. UBC Overhead (30% of 1 and 2)	19,500.	20,820.	11,235.
4. Computing	9,000.	9,000.	5,000.
5. Travel	3,000.	3,000.	1,500.
6. Sub-Contractor	4,000.	4,000.	2,000.
7. Consultants	8,000.	8,000.	8,000.
8. Adm. Charges (2% of 5)	600.	600.	300.
TOTAL ESTIMATED:	107,600.	114,820.	65,485.

B. Equity Silver Mines Budget (Funded by Equity Silver Mines)

	Year 1	Year 2	Year ½
1. Salaries:			
Team Leader (part-time)	25,000.	27,500.	16,000.
Summer Student (4½ mo.)	10,000.	11,000.	-
Technician (4½ mo.)	12,000.	13,200.	4,000.
2. Overhead: (0.8 times 1)	37,600.	41,360.	16,000.
3. Computing	1,000.	1,000.	500.
4. Cost of Prior Data	8,000.		
TOTAL ESTIMATED:	93,600.	94,060.	36,500.

C. Cash Flow Chart

RESERVED FOR CASH FLOW

OUTLINE TO

BE

PREPARED

FOLLOWING

DISCUSSIONS

WITH

EQUITY SILVER
MINES

D. Benefits

1. Technological: Because of the multipurpose objective of this study, a successful application will clearly establish the utility of SPOC methodology for modelling, exploring circuit alternatives, and control evaluation.

2. To Equity Mines: Equity Mines stands to benefit economically in that the study should improve the performance of the existing and expanded circuits.

3. Industry: Industry acceptance of SPOC methodology will be more likely with a valid example documented. The effect should be felt in increased productivity and savings in man-hours.

4. Government: CANMET benefits from credit for their monetary contribution and for directing the SPOC project. The government should benefit through increased productivity and technological advancement.

It is difficult to assess, quantitatively, the economic benefit, because of so many uncertainties. Such efforts may be attempted at the end of the project.

III. REFERENCES

1. Laguitton, D., "SPOC Project: From Theory to Practice, 1981-1982 Progress Report", CANMET Report MRP/MSL 81-152 (OP&J), December, 1981.

2. Mular, A. L., "Empirical Modelling and Optimization of Mineral Processes", Mineral Science and Eng., 4, July, 1972.

3. Mular, A. L., "The Selection of Optimization Methods For Mineral Processes", CIM Special Volume 12, Proc. Int. Symp. on Decision Making in the Mineral Industries, Montreal, June, 1970.

4. Mular, A. L., "Optimization in Flotation Plants", Ch. 31, in Flotation, Ed. M. C. Fuerstenau, AIME, Colorado, 1976.

5. Mular, A. L., "Off-Line Optimization of A Grinding Circuit", XIII International Mineral Processing Congress, Warsaw, 1979, p. 455.

RESUMES OF PROJECT

PERSONNEL

I. A. L. Mular
II. Ivan Eljarbo
III. C. R. Larsen
IV. B. C. Flintoff
V. A. R. LaPlante
VI. D. Hodouin
VII. Research Engineer
VIII. Research Assistant
IX. Computer Programmer
X. Summer Student
XI. Technician

ITEM I

RESUME

Professor A. L. Mular
Department of Mining and Mineral Process Engineering
University of British Columbia
Vancouver, B. C.

EDUCATION:

- BSc Metallurgical Engineering (Mineral Dressing Option), Montana School of Mines 1957, with honour.
- MSc Metallurgical Engineering, (Mineral Dressing Option), Montana School of Mines, 1958.

EXPERIENCE:

- Has held teaching positions at Montana Mines (1956-58), Queen's University (1963-72) and U. B. C. (late 1972-82).
- Has worked in a variety of mineral processing locations both in production and as a consultant.
- Has taught a variety of summer and special courses in the mineral processing area and is author or co-author of 13 texts/manuals and about 52 research publications. Current research is in the area of digital simulation of a concentrator, optimization of mineral processes and models of mineral processes.

RESUME

Mr. Ivan Eljarbo
Senior Metallurgist
Equity Silver Mines Ltd.

EDUCATION: B.A.Sc. Mineral Engineering, University of B. C., 1975

EXPERIENCE: Metallurgist, Sherrit Gordon, Lynn Lake Concentrator, 1975,1977.

Project Engineer, Noranda Research Centre, 1977,1980.

Senior Metallurgist, Equity Silver Mines, 1980-present

Involved in all aspects of process control in production.

Knowledgeable in process modelling and simulation.

RESUME

C. R. Larsen
Senior Process Engineer
Brenda Mines Ltd.
Peachland, B. C.

EDUCATION: B.A.Sc. Mineral Engineering, U.B.C., 1976

EXPERIENCE: Joined Brenda Mines as Process Metallurgist, 1976-present.

Participated in all phases of modelling and simulation of Brenda crushing/grinding circuit.

Developed on-line model of cyclone used for process control.

Involved in process control and general operations at Brenda Mines.

RESUME

Prof. B. C. Flintoff
Department of Mineral Engineering
University of Alberta
Edmonton, Alberta

EDUCATION:

PhD, University of Alberta, 1982 (Mineral Engineering)

EXPERIENCE:

Process Engineer, Brenda Mines, 1973-1978.

Research Assoc., U of A, 1978-1981.

Ass't. Prof., U. of A., 1981-present

Involved in process control and general operations at Brenda Mines.

Assisted in the development of process models, crushing, grinding and flotation, and circuit simulation while at Brenda.

Major research interest, Process Models, Simulation and Control. Stress in coal, but versatile.

ITEM V

RESUME

Prof. A. R. LaPlante
Department of Mining and Metallurgical Engineering
University of McGill
Montreal, Quebec

EDUCATION:

EXPERIENCE:

ITEM.VI

RESUME

Prof. D. Hodouin
Department of Mining Engineering
University of Laval
Quebec City, Quebec

EDUCATION:

EXPERIENCE:

ITEMS VII TO XI

JOB DESCRIPTIONS

VII. Research Engineer: Knowledgeable in modelling and simulation of mineral processes; familiarity with optimization procedures; Programs in BASIC and FORTRAN; Understanding of principles of mineral processing operations; production experience desireable.

VIII. Research Assistant: Graduate Student; Class I average, MASc or PhD level; Canadian or Landed Immigrant.

IX. Computer Programmer: BASIC and FORTRAN programmer; part time; must have ability to follow mathematical details well enough to program them. Converts programs readily from one language to another; modifies programs to conform to particular computer.

X. Summer Student: A 3rd year student from U.B.C., Class I average, who will do his B.A.Sc. thesis, 4th year, on aspects of this project. Will serve as sampler during summer; also lab technician duties.

XI. Technician: Knowledgeable in all phases of lab/sampling methods at Equity Silver Mines.

APPENDIX VII

Example Proposal to

Conduct Off-Line Optimization Studies

RESEARCH PROPOSAL*

TO:

CONDUCT OFF-LINE OPTIMIZATION STUDIES

PREPARED BY:

A. L. Mular
Professor of Mineral Process Engineering
University of British Columbia
Department of Mining and Mineral Process Engineering
Vancouver, B. C.

SUBMITTED TO:

CANMET (SPOC PROJECT)
553 Booth Street
Ottawa, Ontario

November 12, 1982

*EXAMPLE PROPOSAL ONLY. FOR SUBMISSION TO
SPOC STEERING COMMITTEE

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Item I: A. L. Mular	
Item II: C. R. Larsen	
Item III: B. C. Flintoff	
Item IV: A. R. LaPlante	
Item V: D. Hodouin	
Item VI: Research Assistant	
Item VII: Computer Programmer	
Item VIII: Summer Student	
Item IX: Technician	

I. TECHNICAL PROPOSAL

A. Background

Since 1974, Brenda Mines Limited, Peachland, B. C., and the University of British Columbia, Vancouver, B. C., with partial CANMET support, have cooperated jointly to develop a crushing and grinding circuit simulator (1,2). Both Brenda and UBC, since 1980, have been involved with the CANMET-SPOC (Simulated Processing of Ores and Coal) project, which was reviewed by Laguitton (3). Models developed at Brenda Mines include: (a) a standard (secondary) 7 ft cone crusher, (b) a 7 ft shorthead (tertiary) cone crusher, (c) an 8 ft X 20 ft double deck vibrating screen, (d) the primary fines stream tonnage/size distribution, (e) a 13.5 ft X 22 ft overflow ball mill, (f) a 13 ft X 18 ft overflow rod mill, and (g) a 30 inch cyclone classifier. Recently (4), the ball mill model was improved by means of SPOC technology.

With additional effort, the equipment models cited above may be utilized to develop a crushing/grinding circuit "model" for off-line optimization (5,6,7) studies. A direct comparison between prediction and practice is then possible.

B. Objectives

The objectives of this proposal are: (a) to develop constraint expressions for the secondary cone crusher, the rod mill, the pump box, the ball mill and the cyclones, along with circuit constraints, (b) to construct a properly constrained crushing/grinding circuit "model", (c) to use the "model" as a subroutine for an optimization procedure, off-line, that finds the best combination of inputs to satisfy a suitable criterion related to outputs and (d) to compare results with actual performance of the crushing and grinding circuits. Response surface topology, with constraint lines superimposed, will be constructed in suitable dimensions.

C. General Approach

The University of British Columbia will assume contract responsibility for the overall project, with Professor A. L. Mular as principal investigator. Brenda Mines Limited will serve as a sub-contractor, with Mr. C. R. Larsen, senior process engineer, as on-site investigator. Consulting investigators will be Prof. B. C. Flintoff, Prof. A. R. LaPlante, and Prof. D. Hodouin (see sections E. and H.).

Using SPOC technology and any necessary additional techniques to be suitably documented and explained, the project will be conducted in a series of sequential tasks as follows:

Task 1 (Familiarization with SPOC technology and planning): Project personnel will review SPOC documentation and constraint-building procedures. Tentative expressions will be sought to assist in data acquisition and speed the development of constraint expressions. To develop constraint equations, a different approach to data acquisition may be necessary. Brenda models will be reviewed along with record sheets.

Task 2 (Acquisition of constraint data): A planning/sampling team will acquire data in a manner judged necessary to develop constraint equations. Manufacturer literature will be helpful to some extent. Necessary computer programs will be written for fitting constraint expressions to data.

Task 3 (Building constraint equations): Constraint expressions will be fitted to data for each equipment item other than the tertiary crusher and vibrating screen. In so far as is possible, SPOC techniques will be employed. Circuit constraints will be determined.

Task 4 (Construction of crushing/grinding circuit "model"): Models will be connected together, along with corresponding constraints, to form a single crushing/grinding circuit "model". The "model" will be tested over the range of all original data and extrapolated to approach

constraints.

Task 5 (Construction of off-line optimization program): A direct search procedure will be employed as an optimization program, where the "model" serves as a subroutine. An objective function will be formulated and the best combination of operating/design variables associated with the "model" will be found. The response surface or objective function surface will be mapped as a function of variables. Constraints will be superimposed on maps.

Task 6 (Comparison with actual circuits): Variable settings predicted from the off-line study will be compared with actual circuit values. Quite possibly, the crushing/grinding circuits are already operating at best settings. A fair comparison will be attempted.

Task 7 (Final project report): Results of all tasks/comparisons will be documented in sufficient detail to serve as a SPOC manual and for use by Brenda Mines Limited. The University of British Columbia has the responsibility for all report preparation for submission to CANMET, with approval by Brenda Mines Limited prior to release.

D. Potential Problems

Minor problems are foreseen, in that the objective function surface may be multi-nodal. For this reason, the surface must be mapped. Empiricism may be necessary for all constraint relationships.

E. Personnel (See APPENDICES for resumes)

1. A. L. Mular, Professor, University of B. C., Principal Investigator.
2. C. R. Larsen, Senior Engineer, Brenda Mines Limited, On-Site Investigator.
3. B. C. Flintoff, Ass't. Professor, University of Alberta, Consulting Investigator.
4. A. R. LaPlante, Ass't. Professor, McGill University, Consulting Investigator.
5. D. Hodouin, Ass't. Professor, University of Laval, Consulting Investigator.

6. Research Assistant, University of B. C.
7. Computer Programmer, University of B. C.
8. Summer Student, Brenda Mines Limited
9. Technician, Brenda Mines Limited

F. Proprietary Information

Raw data acquired at Brenda Mines Limited for building constraint expressions will be released to SPOC as part of the final report. Graduate student theses at UBC, which involve aspects of the project, will be either published by SPOC of in the normal way. All results are available to Brenda Mines Limited for their use.

G. Sub-Contractor

Brenda Mines Limited agrees to:

(1) Release models currently available to the project, along with information useful to build constraint equations.

(2) Appoint Mr. C. R. Larsen as on-site investigator for on-site activities associated with Tasks 1 to 7.

(3) Permit the acquisition of data for building constraints.

(4) Utilize one technician, part-time, to serve on the sampling team and for associated laboratory measurements.

(5) Make the metallurgical laboratory available for measurements associated with sampling and constraint building.

H. Consulting Investigators

Professors Flintoff, LaPlante and Hodouin agree to serve as consulting investigators on data acquisition, constraint building and programming for approximately one week of their time per year.

I. Planning/Sampling Team

The planning committee will consist of Dr. D. Laguitton, CANMET, as an Observer, Prof. A. L. Mular, Principal Investigator, Mr. R. G. Bradburn, Mill Superintendent, Mr. C. R. Larsen, On-Site Investigator, a research assistant, Profs. Flintoff, LaPlante and Hodouin, Consulting Investigators respectively, and others as designated by Brenda Mines Limited.

The sampling team will consist of Mr. C. R. Larsen, On-Site Investigator, a research assistant, a summer student and a technician. Prof. A. L. Mular will assist Mr. Larsen during portions of the sampling campaign. Some assistance from consulting investigators may likewise be required.

A University of B. C. programmer may be called upon to assist in the conversion of computer programs as necessary. The bulk of the computing effort is expected to reside at UBC, although the optimization program should be mounted in the Brenda system for their use.

The mineral processing laboratory at UBC will be available to the project as required.

J. Time Schedule

An estimated time schedule to complete tasks is as follows:

Task	Estimate of Time To Completion
1	January 1, 1983 to April 30, 1983
2	May 1, 1983 to August 31, 1983
3	September 1, 1983 to December 31, 1983
4	January 1, 1984 to February 28, 1984
5	March 1, 1984 to June 30, 1984
6	July 1, 1984 to August 31, 1984
7	September 1, 1984 to October 31, 1984

The tasks will overlap to some extent, so that times are estimates only. Total time to completion will be 22 months.

K. Project Control

Technical/Accounting control of the project will be provided by the University of British Columbia with Professor A. L. Mular as Principal Investigator. Progress reports will be submitted every two months on behalf of all participants by Professor A. L. Mular.

Accounting will be done by the University of B. C., Department of Finance, based on invoices from sub-contractors/consulting investigators. Invoices for progress payments will be submitted monthly.

II. PRICE PROPOSAL

A. Estimated Budget

This project will be funded by CANMET. One budget will be necessary for UBC and paid in accord with the cash flow structure shown on page 7. The sub-contractor will bill UBC accordingly.

	Year 1	Year 2
1. Salaries:		
Principal Investigator	4,000.	4,000.
Research Assistant	10,500.	10,500.
Programmer (part-time)	6,000.	4,000.
2. Supplies/Expenses/Living accomodation at Brenda.	4,000.	4,000.
3. UBC Overhead (30% of 1 & 2)	7,350.	6,450.
4. Computing	6,000.	6,000.
5. Travel	1,500.	1,500.
6. Sub-Contractor	68,400.	57,600.
On-Site Investigator (part-time)	16,000.	8,000.
Summer Student (4½ mo.)	10,000.	11,000.
Technician (4½ mo.)	12,000.	13,000.
Overhead (.8 times salaries)	30,400.	25,600.
7. Consultants	6,000.	6,000.
8. Adm. Charges (2% of 5)	300.	300.
TOTAL:	114,050	100,350

PROJECT TOTAL: 214,400

B. Cash Flow Chart

RESERVED FOR CASH FLOW SUMMARY

FOLLOWING DISCUSSIONS

WITH BRENDA MINES

C. Benefits

1. Technological: This will be the first study of its kind for mineral processing plants, where both crushing and grinding are involved. A successful application will clearly establish the utility of SPOC methodology for off-line optimization.

2. To Brenda Mines: Brenda Mines stands to benefit economically in that the study should point to "best" combinations of input variables that satisfy an objective function of their choosing.

3. Industry: The implications of a successful off-line optimization study to find "best" input variables are enormous. Studies on paper would save substantially in man-hours and down time for plant changes that involve evaluation projects. For example, rather than study the effect of changes in screen openings at the plant (involving many months of evaluation), the "best" screen size is determined by means of inexpensive off-line studies.

4. Government: CANMET benefits from credit for their monetary contribution and for directing the SPOC project. The government benefits through increased productivity and advanced technology.

It is difficult to assess, quantitatively, the economic benefits, because of so many uncertainties. Such efforts may be attempted at the end of the project.

III. REFERENCES

1. Hatch, C. C., C. R. Larsen and A. L. Mular, "Digital Simulation of The Brenda Mines Ltd. Secondary Crushing Plant--Case Study", Ch. 17 in Design and Installation of Comminution Circuits, Eds. A. L. Mular and G. Jergensen, AIME, Colorado, 1982.

2. C. R. Larsen, 4th Year Thesis, University of B. C., 1976; also Internal Reports, 1976-79, Brenda Mines Limited.

3. Laguitton, D., "SPOC Project: From Theory to Practice, 1981-1982 Progress Report", CANMET Report MRP/MSL 81-152 (OP&J), Dec., 1981.

4. Spring, R., C. R. Larsen and A. L. Mular, Noranda Research Centre Report to CANMET, November, 1982.

5. Mular, A. L., "The Selection of Optimization Methods For Mineral Processes", CIM Special Volume 12, Proc. Int. Symp. on Decision Making in the Mineral Industries, Montreal, June, 1970.

6. Mular, A. L., "Optimization in Flotation Plants", Ch. 31 in Flotation, Ed. M. C. Fuerstenau, AIME, Colorado, 1976.

7. Mular, A. L., "Off-Line Optimization of A Grinding Circuit", XIII International Mineral Processing Congress, Warsaw, 1979, p. 455.

RESUMES OF PROJECT PERSONNEL

I. A. L. Mular
II. C. R. Larsen
III. B. C. Flintoff
IV. A. R. LaPlante
V. D. Hodouin
VI. Research Assistant
VII. Computer Programmer
VIII. Summer Student
IX. Technician

ITEM I

RESUME

Professor A. L. Mular
Department of Mining and Mineral Process Engineering
University of British Columbia
Vancouver, B. C.

EDUCATION:

- BSc Metallurgical Engineering (Mineral Dressing Option), Montana School of Mines 1957, with honour.
- MSc Metallurgical Engineering, (Mineral Dressing Option), Montana School of Mines, 1958.

EXPERIENCE:

- Has held teaching positions at Montana Mines (1956-58), Queen's University (1963-72) and U. B. C. (late 1972-82).
- Has worked in a variety of mineral processing locations both in production and as a consultant.
- Has taught a variety of summer and special courses in the mineral processing area and is author or co-author of 13 texts/manuals and about 52 research publications. Current research is in the area of digital simulation of a concentrator, optimization of mineral processes and models of mineral processes.

RESUME

C. R. Larsen
Senior Process Engineer
Brenda Mines Ltd.
Peachland, B. C.

EDUCATION: B.A.Sc. Mineral Engineering, U.B.C., 1976

EXPERIENCE: Joined Brenda Mines as Process Metallurgist, 1976-present.

Participated in all phases of modelling and simulation of Brenda crushing/grinding circuit.

Developed on-line model of cyclone used for process control.

Involved in process control and general operations at Brenda Mines.

ITEM III.

RESUME

Prof. B. C. Flintoff
Department of Mineral Engineering
University of Alberta
Edmonton, Alberta

EDUCATION: PhD, University of Alberta, 1982 (Mineral Engineering)

EXPERIENCE: Process Engineer, Brenda Mines, 1973-1978.

Research Assoc., U of A, 1978-1981.

Ass't. Prof., U. of A., 1981-present

Involved in process control and general operations at Brenda Mines.

Assisted in the development of process models, crushing, grinding and flotation, and circuit simulation while at Brenda.

Major research interest, Process Models, Simulation and Control. Stress in coal, but versatile.

ITEM IV

RESUME

Prof. A. R. LaPlante
Department of Mining and Metallurgical Engineering
University of McGill
Montreal, Quebec

EDUCATION:

EXPERIENCE:

ITEM V

RESUME

Prof. D. Hodouin
Department of Mining Engineering
University of Laval
Quebec City, Quebec

EDUCATION:

EXPERIENCE:

JOB DESCRIPTIONS

VI. Research Assistant: Graduate student; Class I average; MASc or PhD; Canadian or Landed Immigrant.

VII. Computer Programmer: BASIC and FORTRAN programmer, part-time; ability to follow mathematical details well enough to program them. Converts programs readily from one language to another; modifies programs to conform to various types of computers.

VIII. Summer Student: A 3rd year student from U.B.C., Class I average, who will do his BASc thesis, 4th year, on aspects of this project. Serves as sampler during summer; also lab technician duties.

IX. Technician: Knowledgeable in all phases of lab/sampling methods at Brenda Mines Ltd.

APPENDIX VIII

Evaluation/Comparison

of

Two "Best" Sites

by Dr. A.R. LaPlante

at

Request of Subcommittee

Evaluation of the 'Development of a Grinding Circuit Simulator and Off-Line Optimization Studies' at Equity Silver Mines Ltd.

Prepared by A.R. Laplante

Submitted to:

CANMET (SPOD PROJECT)

553 Booth St.

Ottawa, Ontario

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INTRODUCTION

Equity Silver Mines Ltd. is one of the three sites retained for the demonstration of existing modelling methodology by the SPOC - 3 sub-committee.

This report presents my own evaluation of the project's merits, based largely on sub-committee discussions. The evaluation will be done on a point by point basis, followed by a qualitative analysis of the cost/benefit ratio.

Point 1. Nature of the Problem

The problem is an off-line optimization study of a grinding circuit expansion. As no simulator is available, it will have to be built. It is more than likely that the circuit expansion will be designed and completed before the project is completed. If so, the performance of the expanded circuit will be compared to model predictions.

Application of modelling methodology to the design of circuit changes has excellent potential because of the large capital expenditures involved, and, unlike new plant design, reasonably good knowledge of fullscale ore behaviour. Equity Silver being a relatively new plant, considerable new information should be generated by the project. This should lead to significant operation improvements, even on the existing part of the grinding circuit.

However, I would like to see the problem more specifically defined. The expansion objectives (throughput/size) should be clearly stated, and possibly a cost function (for over/under design) explicated. The importance of the rod mill reduction ratio is a delicate point, and cannot be over-emphasized, because of the weakness of the rod mill model. Assisting in the evaluation of grinding circuit control strategies is not easily performed with steady-state models. It may be preferable to refer to a 'sensitivity analysis of the circuit to operating control variables.' Benefits there too are difficult to quantify.

In summary, the problem is a good one, but it may have to be formulated more specifically. Tasks which are more suited for SPOC methodology should be stressed.

Point 2. Modelling Work Previously Completed at the Site

Very little has been done thus far. This is both a 'pro' and a 'con,' as it should maximize both the benefit and cost of the project. I see it as quite positive, as Phase 3 is 'a selling job' for SPOC methodology, and most potential 'customers' have had little or no modelling experience.

Point 3. Type of Ore

Here we run into a potential problem. Equity silver ore has both significant amounts of sulphides and silicates. The large density difference necessitates at least a two-phase size by size model, especially for classification. This will increase the modelling effort, and require careful experimental design. This is an opportunity to adapt existing SPOC methodology to heterogeneous materials. I think it will make the package more marketable, as most Canadian ores are of heterogeneous rather than homogeneous nature.

Point 4. Personnel

Personnel at Equity Silver has had limited modelling experience, but is dynamic and familiar with the modelling concepts. Close contact with C. Larsen from Brenda Mines throughout the project, as well as other associate investigators, should facilitate the technology transfer. Again this is seen as an attractive feature for the marketing of SPOC, as most Canadian Mines are in the same situation.

Equity Silver also maintains close ties with the Mineral Process Engineering Department of U.B.C., a likely candidate as the chief contractor. This is seen as very positive, because close collaboration between all parties is essential.

Point 5. Equity Silver as a Site

Equity silver enjoys a relatively good visibility Canada-wise. The upcoming plant expansion should augment this visibility, when so many plants are experiencing production decreases or shutdowns.

Accessibility is not outstanding, but I do not think it is an important factor here.

Cost/Benefit Ratio

The expected benefits should be defined at the start of the project, as part of Task 1. Benefits stemming from a better design of the expansion will not actually be realised, if the expansion takes place before Task 7 is completed. Sampling campaigns should be planned before or after, but not during expansion.

The operating efficiency of the circuit should be well characterized at the beginning of the project; otherwise benefits stemming from a better operation will not be convincingly quantified. This appears to have been the case for other similar studies. Operational improvements taking place during the project, not necessarily as a result of Tasks 7 to 10, should be monitored and included in the benefits.

To sum up, I think that the cost/benefit ratio could be attractive. Many of the benefits may be hidden, and these will have to be carefully highlighted.

CONCLUSION

I would rank this project on top of the list. The problem as presented is within SPOC methodology, although some minor adjustments are needed. Two areas of concern are (1) rod mill reduction ratios and (2) ore heterogeneity.

The potential benefits of the project are attractive. Because of the young age of the plant and the forthcoming expansion, significant improvements in operating conditions could be achieved. The suitability of SPOC methodology as a tool for plant expansion design could be demonstrated.

Evaluation of the Off-Line Optimization Study at Brenda Mines Ltd.

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INTRODUCTION

Brenda Mines Ltd. is one of the 3 sites retained for the demonstration of existing modelling technology by the SPOC-3 sub-committee. This report presents my own evaluation of the project's merits, based largely on sub-committee discussions. Similar reports will be presented for the two other sites.

The evaluation will be done on a point by point basis, followed by a qualitative analysis of the cost/benefit ratio.

Point 1. Nature of the Problem

The project is an off-line constrained optimisation study of the crushing/grinding circuits. It will make use of a large number of SPOC models, most of which have already been fitted to Brenda plant data, and found adequate. Deriving operating constraints has not extensively been done before, and should contribute to operator's acceptance of the modelling approach. Development of a constraint building methodology will also be possible. A potential problem is model accuracy: it will have to be very good to detect small potential improvements in operating conditions.

The most important variable of the model might be the particle size at which to stop crushing and start grinding. This is problematical, since it implies that rod mill models can predict accurately the effect of feed size, which they cannot. This particular aspect of the problem will require careful experimental design, and should also yield useful information.

I think the problem at hand is particularly well suited for SPOC Phase 3.

Point 2. Modelling Work Previously Completed at the Site

Brenda Mines has been the location of much grinding and simulation work, which has been well publicized. Significant improvement of production has been achieved. As a result, crushing and grinding models already exist. This would enable the development of a constrained crushing/grinding model for off-line optimisation within a two year period, something impossible elsewhere in Canada at the present time. This has both pro's and con's. The pro's are mostly that the constrained approach is more realistic, and will be accepted more readily by plant people. The con's have to do with the large of work, both past and future, needed to generate such a model. It is likely to scare off someone who would have to start modelling from scratch, and would then fail to achieve the desired effect (of encouraging SPOC use).

Another 'risk' associated with past modelling work at Brenda is that the crushing/grinding circuits are likely to be operated at or very close to optimum conditions. It might then be very satisfying to prove it with an off-time study, but the benefits would be difficult to appraise. I very much doubt that plant people would consider such a proof as important as an actual indication of significant improvements.

I conclude that the extensive past work at Brenda is slightly deleterious in the context of SPOC-3.

Point 3. Type of Ore

Brenda is a porphyric copper deposit, of remarkably constant composition. Its low sulphide content makes it very easily described by a simple size by size model. This is very advantageous for modelling, as no assaying or heavy media separation is required. This is especially important when modelling hydrocyclone classification, and is one of the reasons Brenda was able to develop an excellent hydrocyclone model. One drawback is that most Canadian ores are either more heterogeneous or variable in composition. Thus it would be prefereable, albeit more difficult, to illustrate SPOC modelling methodology using a more complex ore. I feel this last point is important, and warrants further discussions.

Point 4. Noranda's Connection

The name 'Brenda Mines' is associated with the Noranda Group. This will bear on how the project is perceived by the Canadian mining industry. On one hand, Noranda has an excellent reputation, and their involvement will help the project. The back-up of the Noranda Research Centre in Montreal is a significant plus. On the other hand, their involvement with phase II has already associated their name with SPOC, and it can be argued that fresh 'blood' should be brought in.

I personally see the overall effect of choosing a Noranda

property for Phase 3 as positive, because Noranda has plants throughout Canada, and thus can diffuse the technology more widely (although this is largely CANMET's job), and has a Pan-Canadian image.

Point 5. Personnel

The personnel of Brenda Mines has had considerable modelling experience (e.g. C. Larsen), and maintains close ties with the Mineral Process Engineering Department of U.B.C., a likely candidate as the chief contractor. This would facilitate preparing the formal submission and subsequent work. This point is not seen as overwhelming, provided Mr. Larsen is retained as consultant should another site be chosen.

Point 6. Brenda as a Site

One of the specifications of the terms of reference is plant accessibility and visibility. Brenda is not as accessible as a plant located in Central Canada, but I consider visibility a much more important factor. Brenda enjoys a good visibility because of past modelling work, and a large processing capacity.

Cost/Benefit Ratio

This point is critical, first because of the existing economic conjecture, but also because economics is the yardstick with which project viability is assessed by management.

Thus, if the project viability is defined strictly in terms of potential operation improvements, it has limited chances of 'economic viability,' because past work has already reaped most of the benefits modelling can yield.

However, other less tangible benefits can accrue. The development of a constraint building methodology is important, and should be considered a significant benefit. Its economic value is difficult to determine. It must also be perceived as important not only by those interested in the science of modelling--the 'modellers'--but also by mineral processing people at large. If not, the apparent cost/benefit ratio becomes unattractive. This last point warrants further discussion by the steering committee.

CONCLUSION

I feel this project is attractive, but ranks second to the Equity Silver one, whose apparent cost/benefit ratio is more attractive. I also believe that the latter fits the terms of reference of SPOC Phase 3 better.

However, this project deserves support as well. Its merits are significant. It also addresses the problem of constrained modelling, which SPOC will have to deal with eventually.

APPENDIX IX

Example Proposals:

Sample and Apply Material Balance

Computer Programs in a

Coal Preparation Plant

A PROJECT TO:

SAMPLE AND APPLY MATERIAL BALANCE COMPUTER PROGRAMS IN A COAL PREPARATION PLANT

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I TECHNICAL PROPOSAL

A BACKGROUND

The SPOC project is a joint Canadian effort, coordinated by CANMET, which is intended to provide the Canadian mineral and coal industries with state-of-the-art tools for process evaluation, modelling and simulation. The first two phases of SPOC dealt with the collection of the various methodologies into the SPOC documentation and the technology transfer/refinement of techniques respectively. These phases are now complete and the project is ready to move forward into phase III which is an implementation or test phase. It is intended to both demonstrate the utility of the existing techniques as well as to help define areas of future work.

To assist in the organization of this critical phase of the project the SPOC steering committee has structured a subcommittee whose responsibility is to define the potential areas of application within the Canadian coal and mineral industries. The phase III subcommittee is to report to the parent steering committee by December 1, 1982 defining the two best possible sites where the following projects might be conducted:

(1) A demonstration of off-line optimization in a mineral processing concentrator.

(2) A demonstration of the sampling/material balance methodologies in a coal preparation plant.

(3) A review of the existing mathematical models for the various coal and mineral processing units with a recommendation for further work in areas requiring model improvement.

DEVCO's Victoria Junction coal preparation plant has been selected by the subcommittee as one of the possible sites for conducting the sampling/material balance demonstration.

The problems associated with extensive coarse particle sampling and the large data record required to characterize the flowstream in coal preparation will serve as a fair test for the methods which have been developed, in large part, from experience in mineral processing applications.

B OBJECTIVES

The principal objectives of this particular demonstration are to:

(1) Define a sampling campaign in a coal preparation plant which will adequately test the sampling methodology and provide the data for material balance calculations, and,

(2) To test the applicability of material balance computer programs in coal preparation plant applications where either a great deal or very little information is known about flowstream attributes.

The secondary objectives of the demonstration should include;

(1) The design of special tests to be run in concert with the sampling campaign which would allow independent and accurate estimation of solids split. This should provide for some quantification of the extent to which the coal particles are broken in-line.

(2) To incorporate some of the more uncommon methods associated with data acquisition in sampling campaigns such as tracer additions in estimating mass flowrate of solids/water.

Ultimately the objectives will be clearly defined by the contractor and CANMET in such a manner that the maximum amount of information is obtained for the investment.

C GENERAL APPROACH

This demonstration will be supported to some extent by CANMET through a contractual arrangement. The contractor will be either the coal preparation plant operator (i.e DEVCO) or some off-site body (eg. Coal Mining Research Centre) that is mutually acceptable to both the operator and CANMET. In either case it is suggested that Dr. H.W. Smith and Dr. D. Hodouin be retained as consultants/sub-contractors to aid in (technology transfer)/(experimental design and analysis) for sampling and material balancing respectively.

The organization of the project lends itself naturally to a breakdown into a series of four tasks; namely:

(1) Planning the Sampling Campaign

This is probably the most critical phase of the demonstration. The Phase III sub-committee recommends that as a preliminary step in this task, the sampling and material balance consultants be requested to brief all personnel to be involved in the work. This will serve the dual function of transferring the technology as well as helping to ensure a successful demonstration.

The results of this task will be the definition of sampling points, number of increments and total sample weight, method of sampling, sample handling and analysis procedures, etc.. It is suggested that a hybrid scheme be implemented where, for reasons of sample weight, analytical costs, associated special tests etc.. only one process unit or circuit be sampled in the coarse coal area. However, in the fine coal (-0.6mm) preparation circuit, where the

processes are less well understood, a comprehensive sampling campaign should be conducted and possibly repeated under a different set of operating conditions.

(2) Preparation and Sampling

On the basis of the experimental design of task 1 it may be necessary to provide new sampling points in the circuit. Jobs such as this together with the assembly of the required sampling tools and containers etc.. form the preparation stage. Subsequent to preparation the sampling campaigns will be executed. To ensure the best possible chance for success the plant must be operating at, or very near, steady state conditions for the period immediately preceeding and throughout the sampling exercise. The samples will be removed to the laboratory and the appropriate analytical work will be done.

(3) Data Collection and Material Balancing

Depending upon the experimental design and in particular the extent of the flowstream analyses this portion of task(2) will most probably require the greatest time to complete. As a result, a large amount of data will be forthcoming and methods of managing the data base must be developed. The data base has to be consistent with the input requirements for the BILMAT computer program. Once all of the data has been collected the appropriate material balance calculations can be performed, probably by a sub-contractor. At the same time, the results of the special tests, if any, can be examined and, if necessary, communicated to the sub-contractor. Once the material balance calculations are complete the results should be reviewed by the operator for his comments. A demonstration of the

utility of the exercise should be included such as the raw data/adjusted data solids mass split estimates and/or partition curves based upon raw and adjusted data presented for comparative purposes.

(4) Report

The contractor will submit a final report detailing all aspects of the tasks above and serving as a Case Study Chapter in the SPOC documentation. If at all possible the consultants/contractors/operators should attempt to address specific problem situations which might arise in sampling and material balancing but which didn't arise in this demonstration.

D POTENTIAL PROBLEMS

While it is possible to speculate on a number of potential problems which may impact upon the success of this demonstration three of the more serious potential problems are described below:

(1) In-Line Size Degradation

In situations where the coal particles are broken in the process unit or circuit being studied the microvariable mass conservation equations cannot be written. In this case one must resort to macrovariable balances (eg. overall ash, % solids, calorific value etc..). While this is acceptable for simple gross material balances it is of no value in constructing partition curves for estimating process performance for example. Furthermore, separation units such as screens where, apart from size, there is no guarantee that the altributes will be substantially different in the product streams, are not amenable to standard techniques.

It is in this area where the development of special tests would be of value in estimating in-line breakage and at least providing the proper factors for feed reconstitution or providing a minimal material balance data set.

(2) Ill Conditioned Response Surfaces

Since the systems used to prepare coal exhibit some characteristic changes in system performance with changing particle size, it is necessary that each flowstream be characterized by a complete washability analysis to facilitate process evaluation or simulation studies. Under these conditions one can easily imagine cases where each flowstream data set may contain in excess of 40 microvariables alone. In a standard Western Canadian metallurgical coal fines circuit it may be desired to sample and simultaneously solve for 10 flowstreams requiring adjustment on a total of 400 microvariables. Such problems are expected to be ill conditioned where, because of their size, they exhibit very flat response surfaces. If this is true it may be necessary to develop methods of handling the data in subsets perhaps in an iterative fashion, to improve upon the condition of the problem.

(3) Solids Losses/Gains

While this problem may be expected to be small and is generally assumed to be so, it can potentially lead to problems in material balancing. Since heavy medium spearation processes require heavy medium recovery circuits on the separation products, any fine material (either initially in the feed or the product of in-line breakage) may report with the heavy medium and not with the coal or refuse product. The result is that if the recirculating load of coal fines in the heavy medium circuit does not match current steady state operating conditions, changes

in the fine solids content of the products may be observed which are not strictly correlated to changes in the feed.

E PERSONNEL

For the purposes of defining personnel requirements it is assumed that the sampling campaign and project management will be handled by a contractor and that the analytical work will be performed by an independent laboratory on a sub-contract basis.

1. Principal Investigator - this is the individual who represents the contractor.

2. Preparation/Sampling Team - these individuals work under the direction of the principal investigator and are responsible for the preparation and execution of the in-plant sampling campaigns. It is expected that approximately 5 persons will fall into this category.

3. Consultants - there are expected to be two consultants associated with the project. One who has expertise in the design of sampling experiments (eg. Dr. H.W. Smith) and one who has expertise in balancing (eg. Dr. D. Hodouin).

4. Sub-Contractors - there are expected to be at least two sub-contractors involved in this demonstration:

(a) The laboratory responsible for analysing the samples.

(b) The person(s) who will perform the material balance calculations on the raw data derived from sampling.

Of course, it is possible that the contractor may provide all of the personnel requirements in 1, 2 and 4 above. In addition if the technical people exist and CANMET is in agreement, the contractor may fill the consultant's role using in-house expertise.

F PROPRIETARY INFORMATION

The results obtained in raw data acquired on-site during this demonstration will be released to the public domain in the form of a chapter to be included in the SPOC documentation.

G SUB-CONTRACTORS

Sub-contractors will be selected by the contractor. The sub-contract for the analytical work will be either done in-house or through some commercial laboratory (eg. Cyclone Engineering Sales Ltd., Edmonton, Alberta). The sub-contract for the material balance calculations may be done in-house or through some organization with expertise in this area (eg. Laval, CANMET).

H CONSULTANTS

The personnel list for the demonstration includes two consultants to assist in the planning from both the sampling and material balance calculations point of view. In the light of the fact that Dr. H.W. Smith authored the SPOC chapter dealing with sampling and Dr. D. Hodouin

directed the construction of the BILMAT material balance program, these are suggested as the logical candidates. Off-site backup does exist, however, for example;

Sampling: Dr. J. Visman
J. Merks

Material Balances: Laval Staff
CANMET Staff

I PLANNING/SAMPLING TEAMS

The planning team is expected to consist of some subset of the contractor's personnel (section E, items (1), (2)) and the two consultants (section H). It is recommended that prior to the design of the on-site sampling demonstration, the elements of the sampling/material balancing methodologies from phase I of SPOC be reviewed. It is further recommended that a representative of CANMET (eg Dr. D. Laguitton) be present at this session to ensure that the terms of the contract are followed.

The composition of the sampling team is entirely the choice of the contractor. It is suggested that a mix of engineering and technical personnel would be optimal. The former can participate in the campaign design as well as the execution.

J TIME SCHEDULE

The expected time schedule for the project is shown in figure J.1. The tasks defined earlier have been partially broken down to illustrate natural blocks of activity. As shown in this figure the major consumer of time is expected to be the sink-and-float fractionation and the subsequent analysis to be done on each fraction. The 8 month period

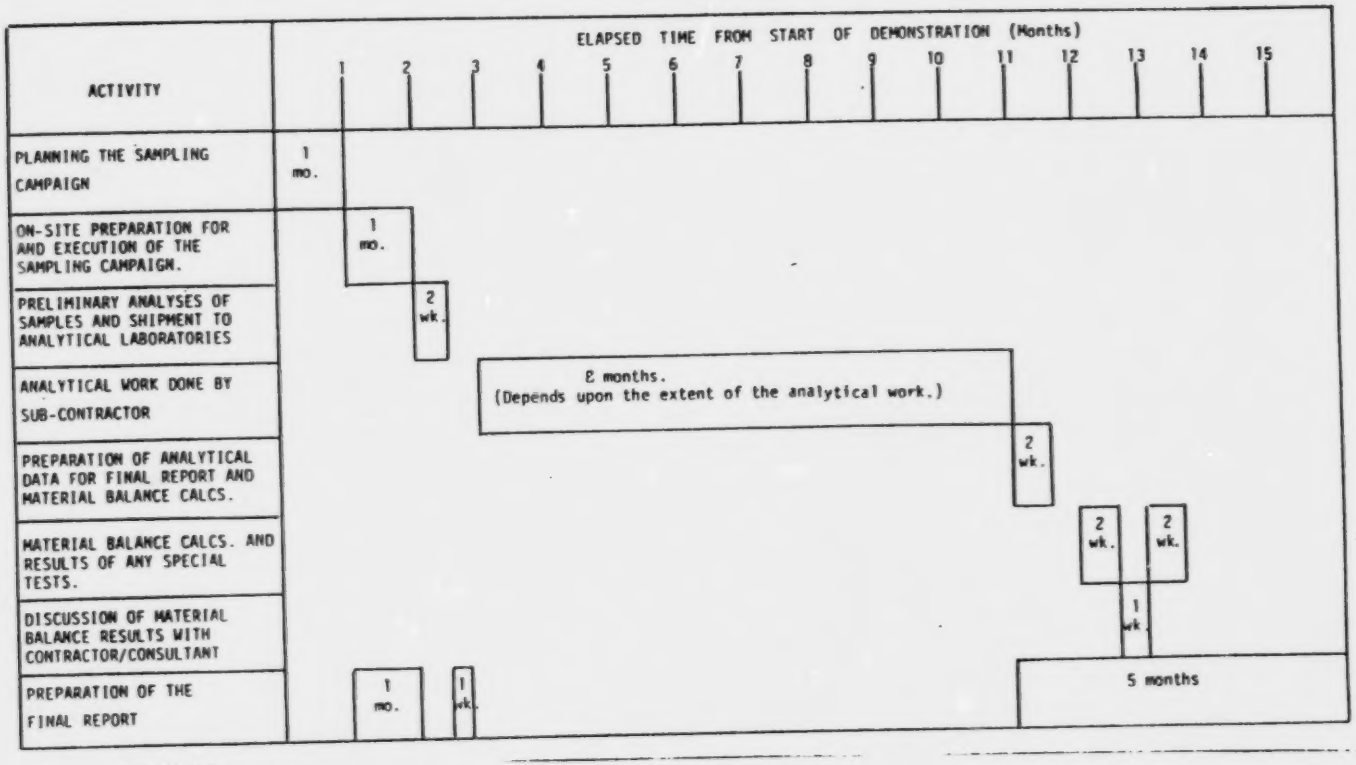

FIGURE J.1 EXPECTED TIME SCHEDULE FOR THE SAMPLING/MATERIAL BALANCE DEMONSTRATION IN A COAL PREPARATION PLANT.

represents a modest sampling campaign as described in Part II. If the project were to begin on June 1, 1983 the expected completion date would be September 30, 1984, or a period of 1 1/3 years.

K PROJECT CONTROL

Technical/Accounting control of the project will be the responsibility of the contractor and will be performed in a manner consistent with DSS regulations.

II PRICE PROPOSAL

Depending upon the contractor this project will be either totally funded by CANMET or jointly funded by CANMET and the contractor. In this case it is expected that DEVCO will absorb some of the costs as outlined in the sample proposal which follows:

N.B. - Since this document doesn't represent a contract proposal, rather it is a working document toward that end, it is difficult to estimate costs. That is, before a price can be agreed upon the objectives of the sampling campaign will have to be clearly defined together with the responsibilities of the parties involved. It is the opinion of the author that having agreed generally on the objectives and fixing costs, the first task (i.e. planning) will require an experimental design which meets the objectives subject to the cost constraints.

A. EXAMPLE OF A SAMPLING CAMPAIGN AT THE VICTORIA JUNCTION COAL PREPARATION PLANT

The flowsheet for this plant is illustrated in figure A.1. On this figure a total of 18 sample points have been identified and categorized into four blocks which may represent 4 separate sampling campaigns.

BLOCK 1: Samples 1, 2, 3 and 4

These samples will provide some mass flow data around one of the in-plant comminution circuits. In addition, samples 2 and 4 will provide information on the effect of crushing on ash and sulfur liberation.

For this circuit, as well as any other coarse coal circuit it is suggested that a special test be run in conjunction with the sampling campaign. The purpose of this test is too establish with some certainty the actual mass split around a separation unit or units. One method of accomplishing this task would be to meter some solids tracer material into the circuit feedstream, upsteam of the sampling point. If the tracer can be selected such that it concentrates in only one of the separator output streams then;

(i) knowing the tracer feedrate and the concentration in the feedstream the coal solids mass flow is calculated.

(ii) knowing the relative tracer concentration in the feed and product streams the mass split can be independently estimated. Of course, the tracer must not be amenable to in-line breakage.

BLOCK 2: Samples 5, 6, 7, 8, 9, 10

Samples 5 and 6 are included to test the effectiveness of the distributor. Samples 6, 7, 8, 9, 10 are to be obtained around one of the primary circuits to simplify the sampling problem. Samples 6, 7 and 8 are used to calculate deslime screen performance. Samples 7, 9 and 10 are used to calculate primary heavy medium cyclone performance. With respect to the latter, the assumption is made that the feed-stream is in equilbrium with the heavy medium circuit.

A special test such as described above is recommended for this circuit as well. If possible the tracer should be chosen to report with the deslime screen O/F and one of the cyclone products to minimize experimental effort.

BLOCK 3: Samples 11, 12, 13

This block will be executed in a manner similar to block 2. However, since the secondary heavy medium cyclones apparently operate from a common feed manifold a composite sample can be obtained. Special tests may also be included in this circuit.

BLOCK 4: Samples 14, 15, 16, 17, 18

In this case special testing is probably unnecessary, however, other forms may be chosen such as a Residence Time Distribution analysis. Since this block of tests will prove to be the cheapest to run and have the highest probability for successful treatment in material balance calculations, several separate sets of samples may be obtained under different operating conditions.

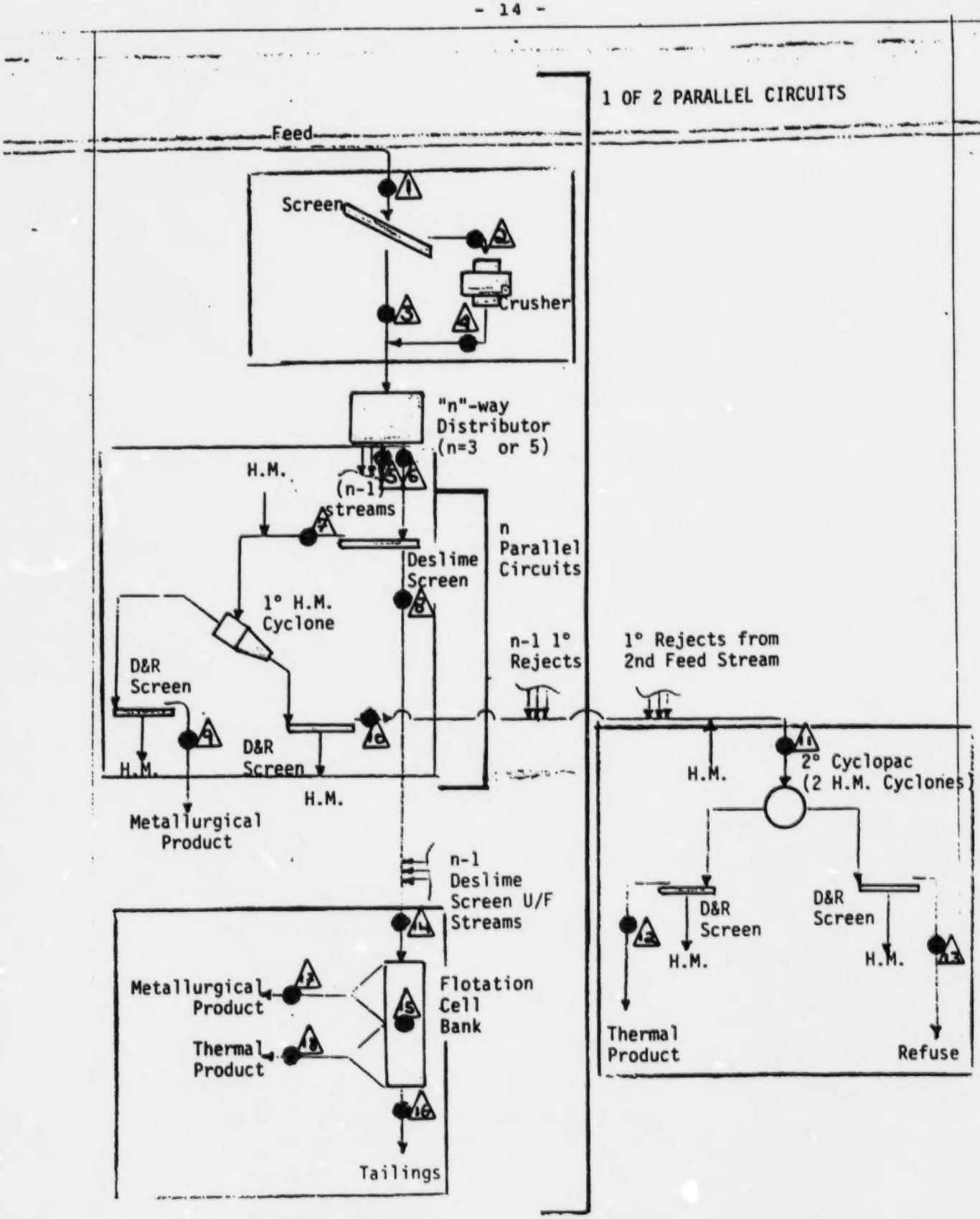

FIGURE A.1 A Schematic of the Victoria Junction Coal Preparation Plant.

B. COST ESTIMATE FOR THE EXAMPLE SAMPLING CAMPAIGN

The estimate of costs for the example sampling campaign are presented below. It is expected that the estimated total cost figure will be on the high side of the true cost.

1.	Salaries	
	Principal Investigator(6 man-months)	$ 19,800
	Preparation/Sampling(5 man-months) Team (1 man month = $3300)	16,500
2.	Supplies/Expenses/Living	$ 15,000
3.	Contractors Overhead (@ 30%)	$ 15,390
4.	Consultants (2@ $200/day & $1000 expenses for 5 days)	$ 5,000
5.	Sub-Contractors	
	(a) Analytical Work (Figure B.1 estimates costs of analysing particulate solids.)	$ 77,130
	(b) Material Balance Calculations	$ 4,000
6.	Travel/Contingency	$ 5,000
	TOTAL COST	$157,820.00

Comment: From figure B.1 it is apparent that considerable cost reduction will result from fewer coarse particle samples, i.e. there is economy in emphasizing the fine coal circuit in designing the sampling campaign.

Figure B.1 ESTIMATION OF ANALYTICAL COSTS

The figures below are based on discussions with a local analytical laboratory. They are expected to be representative but are liberal in the sense that for large jobs costs can be reduced through negotiation.

For the purposes of this work a sieve ratio of ~2 has been assumed for all samples. Also included is the -200M fraction. It is worthy of note that many labs will not perform specific gravity fractionation on this material and it may be necessary to suitably adjust the other size data for its exclusion, prior to calculating the material balance.

Coarse Samples: (Coal nominally -2")

Screen Series

Inch/mesh	Micron
2"	50800
1"	25400
1/2"	12700
4M	4760
8M	2380
16M	1190
28M	595
48M	295
100M	149
200M	74

Costs

(a) S.G. Fractionation (Assuming 7 fractions produced)

$2180/sample

(b) Analyses for ash, sulfur and calorific value

$3080/sample

Total Cost/Coarse Sample = $5260

Fine Samples: (Coal nominally -28M)

Screen Series

Inch/mesh	Microns
28M	595
48M	295
100M	149
200M	74

Costs

(a) S.G. Fractionation (Assuming 7 fractions produced)

$350/sample

(b) Analyses for ash, sulfur and calorific value

$1400/sample

Total Cost/Fine Sample = $1750

C. COST SHARING SCENARIO

Since CANMET appears to favour cost sharing on these kinds of joint ventures a possible project financing scenario may be of the form;

DEVCO acts as the contractor supplying the personnel under item 1. If local people are used item 2 can be excluded from the list. If DEVCO absorbs the costs associated with items 1, 3 and 6 their net contribution to the project would be on the order of $52,190. Items 4 and 5 would be costs borne by contractial funding. It is possible that the analytical costs may be reduced either by altering the sampling design or through contribution of DEVCO resources to this work. These would be items of negotiation in the final agreement. Under this scenario the approximate costs split would be:

DEVCO	$ 52,190(40%)
CANMET	77,630(60%)
TOTAL	$129,820

D. COST BENEFIT ANALYSIS

While the cost of this demonstration is high relative to the pure process information obtained the overall benefits will far exceed the costs. Benefits will accrue in four areas;

The Technology - the successful demonstration of SPOC technology in the coal sector will provide a bench mark for future activities. The complexities of the sampling and material balance problem in coal should provide a thorough "shakedown" of current methods

and help to define areas of future work. Included in this is the area of "special-testing".

DEVCO - the benefits to DEVCO are twofold. Firstly, they will receive "hands-on" exposure to the sampling and material balance methodology and secondly they will have the results of the process performance evaluation.

Industry - the benefits to the coal processing industry arise directly from the successful demonstration of the methodologies in an operating plant under the direction of operating personnel

Government - CANMET benefits both in terms of credit for their significant contribution in the SPOC project and the likelihood of additional funding based on the results. The Government, as always, benefits through taxation on incremental income attributable to more sophisticated process monitoring and control.

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November 8th, 1982

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B1P 6Y3

Dear John,

Enclosed is my proposed submission to the SPOC steering committee regarding a sampling/material balance demonstration at the Victoria Junction Coal Preparation Plant. Please read it critically and communicate any errors to me at your earliest convenience.

Once again, on behalf of the SPOC phase III subcommittee, I would like to thank you for the support that both you and your company are providing in this endeavour.

Best Regards,

B.C. Flintoff,
Assistant Professor of Mineral Engineering

BCF/mf
Encl.

c.c. A.L. Mular, Dept. of Mining and Mineral Process Engineering, University of British Columbia

A PROJECT TO:

SAMPLE AND APPLY MATERIAL BALANCE COMPUTER PROGRAMS IN A COAL PREPARATION PLANT

Prepared by:

B.C. Flintoff

Department of Mineral Engineering

University of Alberta

Edmonton, Alberta

Submitted to:

LUSCAR STERCO(1977) LTD.
AND THE SPOC PROJECT STEERING COMMITTEE

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I TECHNICAL PROPOSAL

A BACKGROUND

The SPOC project is a joint Canadian effort, coordinated by CANMET, which is intended to provide the Canadian mineral and coal industries with state-of-the-art tools for process evaluation, modelling and simulation. The first two phases of SPOC dealt with the collection of the various methodologies into the SPOC documentation and the technology transfer/refinement of techniques respectively. These phases are now complete and the project is ready to move forward into phase III which is an implementation or test phase. It is intended to both demonstrate the utility of the existing techniques as well as to help define areas of future work.

To assist in the organization of this critical phase of the project the SPOC steering committee has structured a subcommittee whose responsibility is to define the potential areas of application within the Canadian coal and mineral industries. The phase III subcommittee is to report to the parent steering committee by December 1, 1982 defining the two best possible sites where the following projects might be conducted:

(1) A demonstration of off-line optimization in a mineral processing concentrator.

(2) A demonstration of the sampling/material balance methodologies in a coal preparation plant.

(3) A review of the existing mathematical models for the various coal and mineral processing units with a recommendation for further work in areas requiring model improvement.

Luscar Sterco's Coal Valley coal preparation plant has been selected by the subcommittee as one of the possible sites for conducting the sampling/material balance demonstration.

The problems associated with extensive coarse particle sampling and the large data record required to characterize the flowstream in coal preparation will serve as a fair test for the methods which have been developed, in large part, from experience in mineral processing applications.

B OBJECTIVES

The principal objectives of this particular demonstration are to:

(1) Define a sampling campaign in a coal preparation plant which will adequately test the sampling methodology and provide the data for material balance calculations, and,

(2) To test the applicability of material balance computer programs in coal preparation plant applications where either a great deal or very little information is known about flowstream attributes.

The secondary objectives of the demonstration should include;

(1) The design of special tests to be run in concert with the sampling campaign which would allow independent and accurate estimation of solids split. This should provide for some quantification of the extent to which the coal particles are broken in-line.

(2) To incorporate some of the more uncommon methods associated with data acquisition in sampling campaigns such as tracer additions in estimating mass flowrate of solids/water.

Ultimately the objectives will be clearly defined by the contractor and CANMET in such a manner that the maximum amount of information is obtained for the investment.

C GENERAL APPROACH

This demonstration will be supported to some extent by CANMET through a contractual arrangement. The contractor will be either the coal preparation plant operator (Luscar Sterco) or some off-site body (eg. Coal Mining Research Centre) that is mutually acceptable to both the operator and CANMET. In either case it is suggested that Dr. H.W. Smith and Dr. D. Hodouin be retained as consultants/sub-contractors to aid in (technology transfer)/(experimental design and analysis) for sampling and material balancing respectively.

The organization of the project lends itself naturally to a breakdown into a series of four tasks; namely:

(1) Planning the Sampling Campaign

This is probably the most critical phase of the demonstration. The Phase III sub-committee recommends that as a preliminary step in this task, the sampling and material balance consultants be requested to brief all personnel to be involved in the work. This will serve the dual function of transferring the technology as well as helping to ensure a successful demonstration.

The results of this task will be the definition of sampling points, number of increments and total sample weight, method of sampling, sample handling and analysis procedures, etc.. It is suggested that a hybrid scheme be implemented where, for reasons of sample weight, analytical costs, associated special tests etc.. only one process unit or circuit be sampled in the coarse coal area. However, in the fine coal (-0.6mm) preparation circuit, where the

processes are less well understood, a comprehensive sampling campaign should be conducted and possibly repeated under a different set of operating conditions.

(2) Preparation and Sampling

On the basis of the experimental design of task 1 it may be necessary to provide new sampling points in the circuit. Jobs such as this together with the assembly of the required sampling tools and containers etc.. form the preparation stage. Subsequent to preparation the sampling campaigns will be executed. To ensure the best possible chance for success the plant must be operating at, or very near, steady state conditions for the period immediately preceeding and throughout the sampling exercise. The samples will be removed to the laboratory and the appropriate analytical work will be done.

(3) Data Collection and Material Balancing

Depending upon the experimental design and in particular the extent of the flowstream analyses this portion of task(2) will most probably require the greatest time to complete. As a result, a large amount of data will be forthcoming and methods of managing the data base must be developed. The data base has to be consistent with the input requirements for the BILMAT computer program. Once all of the data has been collected the appropriate material balance calculations can be performed, probably by a sub-contractor. At the same time, the results of the special tests, if any, can be examined and, if necessary, communicated to the sub-contractor. Once the material balance calculations are complete the results should be reviewed by the operator for his comments. A demonstration of the

utility of the exercise should be included such as the raw data/adjusted data solids mass split estimates and/or partition curves based upon raw and adjusted data presented for comparative purposes.

(4) Report

The contractor will submit a final report detailing all aspects of the tasks above and serving as a Case Study Chapter in the SPOC documentation. If at all possible the consultants/contractors/operators should attempt to address specific problem situations which might arise in sampling and material balancing but which didn't arise in this demonstration.

D POTENTIAL PROBLEMS

While it is possible to speculate on a number of potential problems which may impact upon the success of this demonstration three of the more serious potential problems are described below:

(1) In-Line Size Degradation

In situations where the coal particles are broken in the process unit or circuit being studied the microvariable mass conservation equations cannot be written. In this case one must resort to macrovariable balances (eg. overall ash, % solids, calorific value etc..). While this is acceptable for simple gross material balances it is of no value in constructing partition curves for estimating process performance for example. Furthermore, separation units such as screens where, apart from size, there is no guarantee that the altributes will be substantially different in the product streams, are not amenable to standard techniques.

It is in this area where the development of special tests would be of value in estimating in-line breakage and at least providing the proper factors for feed reconstitution or providing a minimal material balance data set.

(2) Ill Conditioned Response Surfaces

Since the systems used to prepare coal exhibit some characteristic changes in system performance with changing particle size, it is necessary that each flowstream be characterized by a complete washability analysis to facilitate process evaluation or simulation studies. Under these conditions one can easily imagine cases where each flowstream data set may contain in excess of 40 microvariables alone. In a standard Western Canadian metallurgical coal fines circuit it may be desired to sample and simultaneously solve for 10 flowstreams requiring adjustment on a total of 400 microvariables. Such problems are expected to be ill conditioned where, because of their size, they exhibit very flat response surfaces. If this is true it may be necessary to develop methods of handling the data in subsets perhaps in an iterative fashion, to improve upon the condition of the problem.

(3) Solids Losses/Gains

While this problem may be expected to be small and is generally assumed to be so, it can potentially lead to problems in material balancing. Since heavy medium spearation processes require heavy medium recovery circuits on the separation products, any fine material (either initially in the feed or the product of in-line breakage) may report with the heavy medium and not with the coal or refuse product. The result is that if the recirculating load of coal fines in the heavy medium circuit does not match current steady state operating conditions, changes

in the fine solids content of the products may be observed which are not strictly correlated to changes in the feed.

E PERSONNEL

For the purposes of defining personnel requirements it is assumed that the sampling campaign and project management will be handled by a contractor and that the analytical work will be performed by an independent laboratory on a sub-contract basis.

1. Principal Investigator - this is the individual who represents the contractor.

2. Preparation/Sampling Team - these individuals work under the direction of the principal investigator and are responsible for the preparation and execution of the in-plant sampling campaigns. It is expected that approximately 5 persons will fall into this category.

3. Consultants - there are expected to be two consultants associated with the project. One who has expertise in the design of sampling experiments (eg. Dr. H.W. Smith) and one who has expertise in balancing (eg. Dr. D. Hodouin).

4. Sub-Contractors - there are expected to be at least two sub-contractors involved in this demonstration:

(a) The laboratory responsible for analysing the samples.

(b) The person(s) who will perform the material balance calculations on the raw data derived from sampling.

Of course, it is possible that the contractor may provide all of the personnel requirements in 1, 2 and 4 above. In addition if the technical people exist and CANMET is in agreement, the contractor may fill the consultant's role using in-house expertise.

F PROPRIETARY INFORMATION

The results obtained in raw data acquired on-site during this demonstration will be released to the public domain in the form of a chapter to be included in the SPOC documentation.

G SUB-CONTRACTORS

Sub-contractors will be selected by the contractor. The sub-contract for the analytical work will be either done in-house or through some commercial laboratory (eg. Cyclone Engineering Sales Ltd., Edmonton, Alberta). The sub-contract for the material balance calculations may be done in-house or through some organization with expertise in this area (eg. Laval, CANMET).

H CONSULTANTS

The personnel list for the demonstration includes two consultants to assist in the planning from both the sampling and material balance calculations point of view. In the light of the fact that Dr. H.W. Smith authored the SPOC chapter dealing with sampling and Dr. D. Hodouin

directed the construction of the BILMAT material balance program, these are suggested as the logical candidates. Off-site backup does exist, however, for example;

Sampling: Dr. J. Visman
J. Merks

Material Balances: Laval Staff
CANMET Staff

I PLANNING/SAMPLING TEAMS

The planning team is expected to consist of some subset of the contractor's personnel (section E, items (1), (2)) and the two consultants (section H). It is recommended that prior to the design of the on-site sampling demonstration, the elements of the sampling/material balancing methodologies from phase I of SPOC be reviewed. It is further recommended that a representative of CANMET (eg Dr. D. Laguitton) be present at this session to ensure that the terms of the contract are followed.

The composition of the sampling team is entirely the choice of the contractor. It is suggested that a mix of engineering and technical personnel would be optimal. The former can participate in the campaign design as well as the execution.

J TIME SCHEDULE

The expected time schedule for the project is shown in figure J.1. The tasks defined earlier have been partially broken down to illustrate natural blocks of activity. As shown in this figure the major consumer of time is expected to be the sink-and-float fractionation and the subsequent analysis to be done on each fraction. The 8 month period

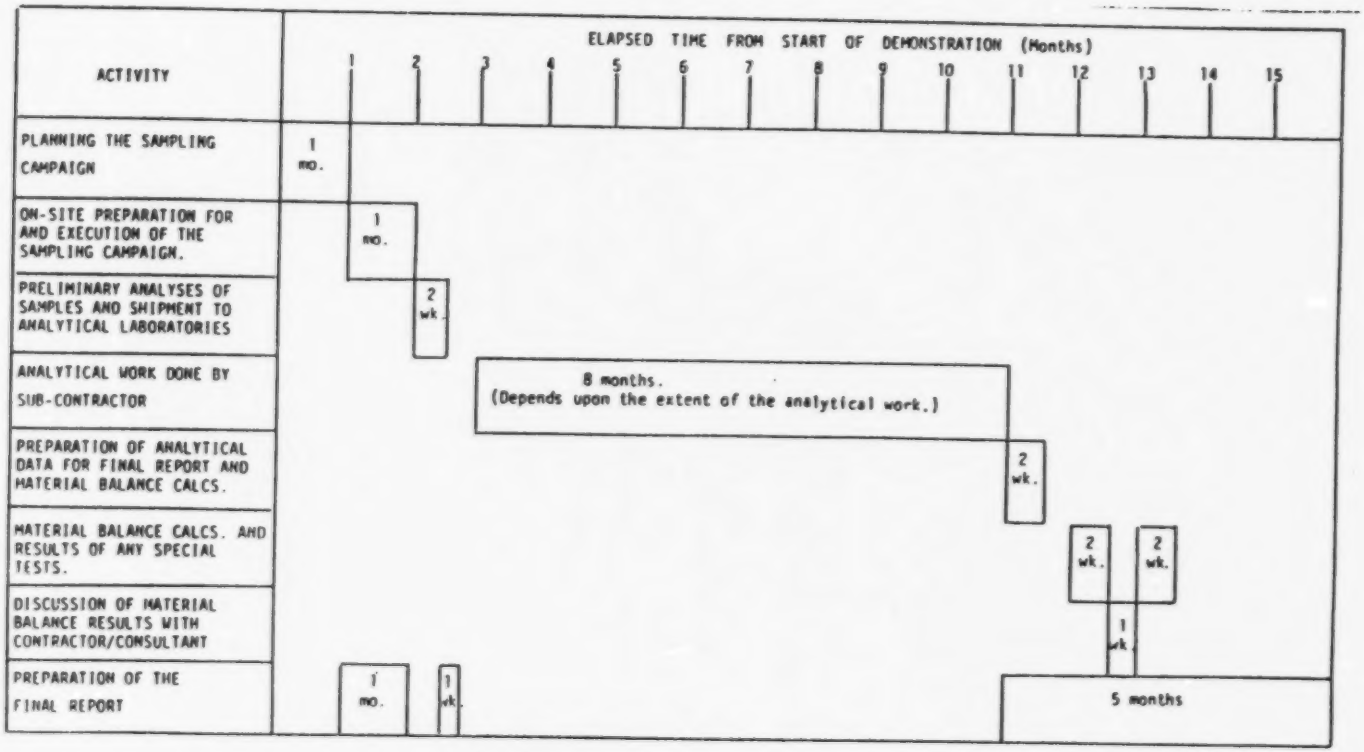


FIGURE J.1 EXPECTED TIME SCHEDULE FOR THE SAMPLING/MATERIAL BALANCE DEMONSTRATION IN A COAL PREPARATION PLANT.

represents a modest sampling campaign as described in Part II. If the project were to begin on June 1, 1983 the expected completion date would be September 30, 1984, or a period of 1 1/3 years.

K PROJECT CONTROL

Technical/Accounting control of the project will be the responsibility of the contractor and will be performed in a manner consistent with DSS regulations.

II PRICE PROPOSAL

Depending upon the contractor this project will be either totally funded by CANMET or jointly funded by CANMET and the contractor. In this case it is expected that Luscar Sterco will absorb some of the costs as outlined in the sample proposal which follows:

N.B. - Since this document doesn't represent a contract proposal, rather it is a working document toward that end, it is difficult to estimate costs. That is, before a price can be agreed upon the objectives of the sampling campaign will have to be clearly defined together with the responsibilities of the parties involved. It is the opinion of the author that having agreed generally on the objectives and fixing costs, the first task (i.e. planning) will require an experimental design which meets the objectives subject to the cost constraints.

A EXAMPLE OF A SAMPLING COMPAIGN AT THE LUSCAR STERCO COAL PREPARATION PLANT

The flowsheet for this plant is illustrated in figure A.1. On this figure a total of 26 sampling points have been identified and categorized into three blocks which may represent four separate sampling campaigns.

Block 1. Samples 1→8

These samples will provide some mass flow data around the coarse coal washing circuit. In addition, sample pairs 5/6 and 8/2 will provide information on the effect of crushing on size reduction and ash liberation. For samples around the heavy medium vessel the assumption that feed-steam is in equilibrium with the heavy medium circuit will be made.

For this circuit, as well as any other coarse coal circuit it is suggested that a special test be run in conjunction with the sampling campaign. The purpose of this test would be to establish with some certainty the actual mass split around a separtion unit or units. One method of accomplishing this task would be to meter some solids tracer material into the feed-stream, upstream of the first sampling point. If the tracer can be selected such that it concentrates in only one of the separator output streams then;

(1) Knowing the tracer feedrate and the concentration in the feed-stream the coal solids mass flow is calculated.

(2) Knowing the relative tracer concentration in the feed and product streams the mass split can be independently estimated. Of course,

the tracer, unlike the coal, must not be amenable to in-line breakage. If possible the tracer should be chosen to concentrate in the screen O/F and one of the bath products, to minimize experimental effort.

Block 2. Samples 9→13

These samples will provide some mass flow data around the intermediate size coal washing circuit. Rather than attempt to composite all six parallel circuits it is suggested that a single circuit be chosen for this work. As in the case of block 1, it will be assumed that the feed-stream is equilibrium with the heavy medium circuit.

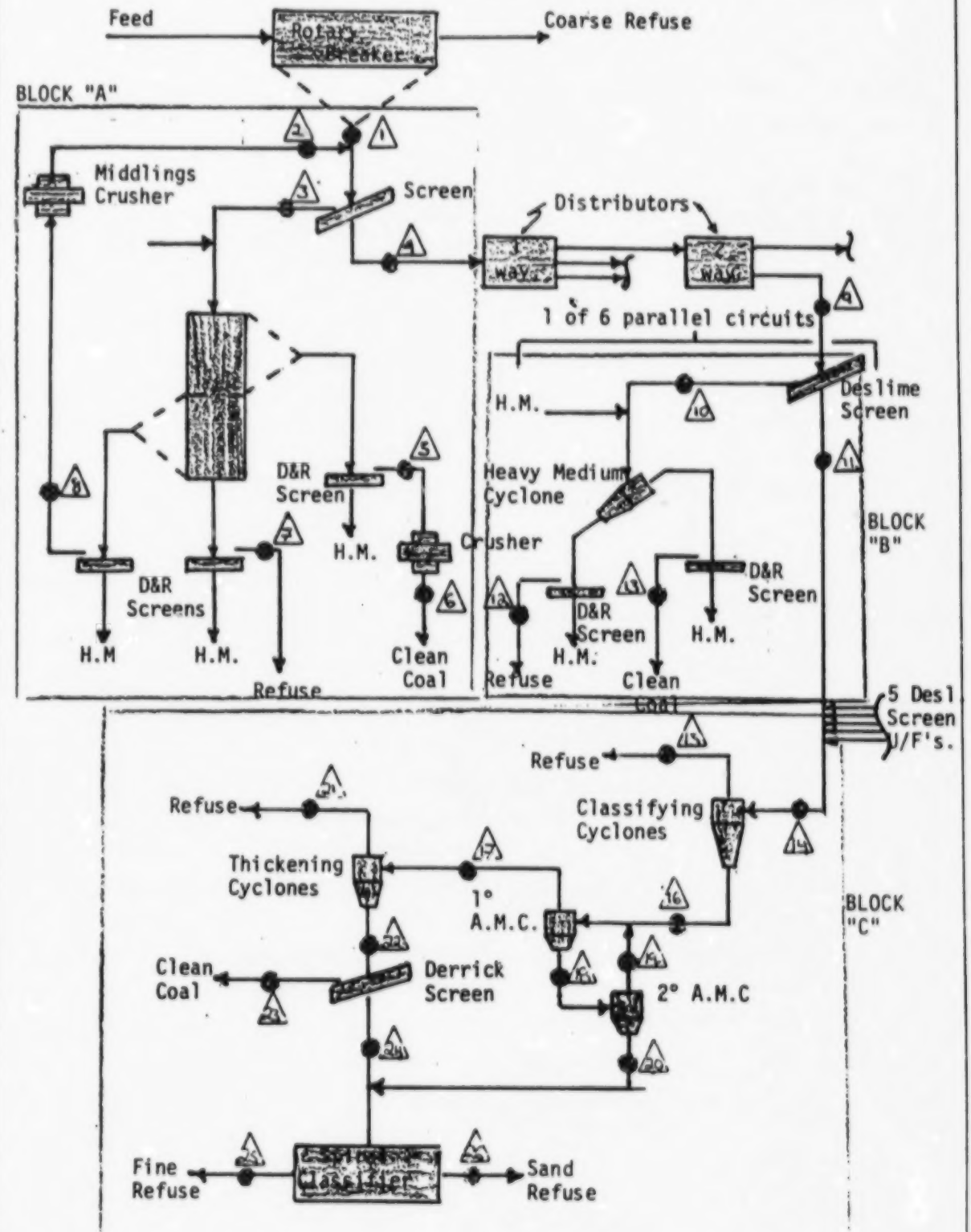
A special test as described above is recommended for this circuit.

Block 3. Samples 14→26

These samples will provide some mass flow data around the fine coal washing circuit. Several of the ancilliary dewatering units have been included since they are conventional solid-solid separation devices.

In this case special testing is probably unnecessary.

FIGURE A.1 LUSCAR-STERCO(1977) LTD. COAL PREPARATION PLANT FLOWSHEET



B COST ESTIMATE FOR THE EXAMPLE SAMPLING CAMPAIGN

The estimate of costs for the example sampling campaign are presented below. It is expected that the estimated total cost will be on the high side of the true cost.

1.	Salaries	
	Principal Investigator(6 man-months)	$ 19,800
	Preparation/Sampling(5 man-months) (1 man-month = $3300.00)	$ 16,500
2.	Supplies/Expenses/Living	$ 15,000
3.	Contractors Overhead (@ 30%)	$ 15,390
4.	Consultants (2 @ $200/day & $1000 expenses for 5 days)	$ 5,000
5.	Sub Contractors	
	(a) Analytical Work (Figure B.1 estimates costs of analysing particulate solids)	$ 91,130
	(b) Material Balance Calculations	$ 4,000
6.	Travel/Contingency	$ 5,000
	TOTAL COST	$171,820

COMMENT: From figure B.1 it is apparent that considerable cost reduction will result from fewer coarse particle samples, i.e. there is economy in emphasizing the fine coal circuit in designing the sampling campaign.

Figure B.1 ESTIMATION OF ANALYTICAL COSTS

The figures below are based on discussions with a local analytical laboratory. They are expected to be representative but are liberal in the sense that for large jobs costs can be reduced through negotiation.

For the purposes of this work a sieve ratio of ~2 has been assumed for all samples. Also included is the -200M fraction. It is worthy of note that many labs will not perform specific gravity fractionation on this material and it may be necessary to suitably adjust the other size data for its exclusion, prior to calculating the material balance.

Coarse Samples: (Coal nominally -4")

Screen Series

Inch/mesh	Micron
2"	50800
1"	25400
1/2"	12700
4M	4760
8M	2380
16M	1190
28M	595
48M	295
100M	149
200M	74

Costs

(a) S.G. Fractionation (Assuming 7 fractions produced)

$2180/sample

(b) Analyses for ash, sulfur and calorific value

$3080/sample

Total Cost/Coarse Sample = $5260

Fine Samples: (Coal nominally -28M)

Screen Series

Inch/mesh	Microns
28	595
48	295
100	149
200	74

Costs

(a) S.G. Fractionation (Assuming 7 fractions produced)

$350/sample

(b) Analyses for ash, sulfur and calorific value

$1400/sample

Total Cost/Fine Sample = $1750

C COST SHARING SCENARIO

Since CANMET appears to favour cost sharing on these kinds of joint ventures a possible project financing scenario may be of the form;

The Coal Mining Research Centre (CMRC) acts as the contractor with Luscar Sterco providing two of 5 man-months under item (1) with a consequent reduction in items(2) and (3). In addition Luscar Sterco will arrange to have the solids sample analysis done through their (i.e corporate as well as plant) laboratories for one half of the cost estimated in Section B above. It is possible that the analytical costs may be reduced either by altering the sampling design or through further contribution of Luscar's resources to this work. These would be items of negotiation in the final agreement. The costs under item 4 would be absorbed by the contractor. Under this scenario the approximate costs split would be:

Luscar Sterco	$ 52,600	
CANMET (to CMRC)	61,910	$107,040
to Luscar Sterco)	45,130	
TOTAL	$159,640	

D COST BENEFIT ANALYSIS

While the cost of this demonstration is high relative to the pure process information obtained the overall benefits will far exceed the costs. Benefits will accrue in four areas;

The Technology - the successful demonstration of SPOC technology in the coal sector will provide a bench mark for future activities. The complexities of the sampling and material balance problem in coal should provide a thorough "shakedown" of current methods

and the help to define areas of future work. Included in this is the area of "special-testing".

Luscar Sterco -the benefits to Luscar-Sterco are twofold. They will receive "hands-on" exposure to the sampling and material balance methodology and secondly they will have the results of the process performance evaluation.

Industry - the benefits to the coal processing industry arise directly from the successful demonstration of the methodologies in an operating plant under the direction of operating personnel.

Government - CANMET benefits both in terms of credit for their significant contribution in the SPOC project and the likelihood of additional funding based on the results. The government, as always, benefits through taxation on incremental income attributable to more sophisticated process monitoring and control.

DEPARTMENT OF
MINERAL ENGINEERING
THE UNIVERSITY OF ALBERTA
Edmonton • Alberta • Canada • T6G 2G6 • Telephone (403) 432-3337

November 15th, 1982

Mr. Mike Iliffe,
Engineering Department,
Luscar Sterco(1977) Ltd.,
Coal Valley, Alberta

Dear Mike;

Enclosed is my proposed submission to the SPOC Steering Committee regarding a sampling/material balance demonstration at the Luscar Sterco coal preparation plant. Please read it critically and communicate any errors to me at your earliest convenience.

You will observe that I have not included any explicit reference to the material which may be processed during the demonstration. This is simply your decision with respect to the timing of the campaign. Furthermore, recalling an earlier telephone conversation in which it was suggested that your on-site and corporate laboratory facilities might be available to assist in the analytical work, I've included this in the budget for the example sampling campaign. I hope this will not create any difficulty, however, it can be modified if you so desire.

Once again, on behalf of the SPOC phase III subcommittee, I would like to thank you for the support that both you and your company are providing in this endeavour.

Best Regards,

Brian C Flintoff

B.C. Flintoff,
Assistant Professor of Mineral Engineering

BCF/mf
Encl.

c.c. A.L. Mular, Department of Mining and Mineral Process Engineering
University of British Columbia

APPENDIX X

Example Proposal to Develop a Rod Mill Model

RESEARCH PROPOSAL

TO

DEVELOP A ROD MILL MODEL SUITABLE FOR DESIGN AND SIMULATION STUDIES

Prepared by

W.A. Dutton

Submitted to:
CANMET (SPOC PROJECT)
553 Booth Street
Ottawa, Ontario

October 20, 1982

Note: This proposal is to be used as a sample. There has been no discussions with the various investigators on their roles and/or commitments to this project.

I. TECHNICAL PROPOSAL

A. BACKGROUND

In April 1980, CANMET initiated a Canada-wide project(1), entitled Simulated Processing of Ore and Coal (SPOC), to provide the mining industry with current computer methodology for process evaluation and optimization. One of the unit operations for which a model has been developed is the ball mill, but additional work is deemed necessary on the rod mill. Rod mill models are currently available(2) but their range of usefulness and validity is questionable.

B. OBJECTIVE

The objective of this study is to develop a rod mill model which (i) incorporates the latest available theory, (ii) simulates real data from several industrial rod mills, (iii) can be used to effectively predict the size distribution of rod mill discharge, and (iv) is compatible with the SPOC simulator and other SPOC programs.

C. APPROACH

McGill University will assume contract responsibility for the overall project with Prof. A. Laplante as principle investigator. Kidd Creek will serve as subcontractor, with Mr. C.R. Larsen (senior process engineer) Brenda Mines Ltd. as consultant. Associate Investigators will be Prof. D. Hodouin, (Laval University), Prof. J. Finch (McGill University), Prof. B.C. Flintoff (University of Alberta), and Prof. A.L. Mular (University of British Columbia).

Task 1 - (State-of-the-Art Review and Familiarization): Project personnel will review SPOC documentation, SPOC computer programs, and the SPOC methodology for model building and validation, and the existing models for rod mills. Discussions involving all investigators will determine the

most likely model form to be used, and the specific data required to validate that model.

Task 2-A (Data Acquisition Around a Rod Mill): A planning/sampling team will acquire data around Kidd Creek rod mills in accord with the SPOC methodology. Existing rod mill data will also be evaluated to assess its usefulness to the modeling task at hand.

Task 2-B (Data Acquisition Around Laboratory Mills): In parallel with plant sampling, extensive laboratory testing will be made, using small batch (to determine the effect of size distribution on grinding kinetics) and continuous (to measure longitudinal classification) mills.

Task 3 (Development of a Rod Mill Model): Using the SPOC methodology, a mathematical model of the rod mill will be developed and validated using the collected data. The McGill computer facilities will be used and those at CANMET will serve as back-up.

Task 4 (Validation of Rod Mill Model in Another Plant): The model will be used to predict the rod mill discharge under known operating conditions at another plant (additional sampling may be necessary)*. The predicted results will be compared with actual operating results.

Task 5 (Documentation and Final Project Report): The results of all tasks/comparisons will be documented in sufficient detail to serve as a SPOC manual and for use by Kidd Creek Limited. McGill University has the responsibility for all report preparation for submission to CANMET subject to approval by Kidd Creek prior to release.

D. POTENTIAL PROBLEMS

Problems are forseen in building a rod mill model which has sufficient generality to be useful without requiring a massive amount of

---

* cost of travel and sampling not included in budget estimate.

validation for a specific combination of mill and ore. An additional complication is caused by 2-phase ore found at Kidd Creek which may require a more complex model than single phase orebodies.

E. PERSONNEL(See Appendix I for resumes)

1. A. Laplante, Professor, McGill University, Principle Investigator
2. C.R. Larsen, Senior Engineer, Brenda Mines, Consultant
3. D. Hodouin, Professor, Laval University, Associate Investigator
4. J. Finch, Professor, McGill University, Associate Investigator
5. B.C. Flintoff, Professor, University of Alberta, Associate Investigator
6. A.L. Mular, Professor, University of B.C., Associate Investigator
7. Research Assistant, McGill
8. Summer Student, Kidd Creek Ltd.
9. Technician, Kidd Creek Ltd.
10. On-site Engineer, Kidd Creek Ltd.

F. PROPRIETARY INFORMATION

Raw data acquired at Kidd Creek Ltd. for building the rod mill model will be released to SPOC as part of the final report. Student theses which involve aspects of the project will be either published by SPOC, or in the normal way. All results will be available to Kidd Creek Ltd. for their use.

G. SUB-CONTRACTOR

Kidd Creek Ltd. agrees to :

1. Release models and data currently available to the project along with any additional information which may be useful to the development of a rod mill model.
2. Appoint an on-site Engineer for on-site activities associated with Tasks 1 to 5.
3. Permit the acquisition of data for building the model.
4. Utilize one technician, part-time, to serve on the sampling team and for associated laboratory measurements.

5. Employ one summer student for data acquisition purposes and laboratory work.
6. Make the metallurgical laboratory available for measurements associated with the sampling and model building and verification.

H. ASSOCIATE INVESTIGATORS AND CONSULTANT

The associate investigators named, D. Hodoin, J. Finch, B. Flintoff and A. Mular have agreed to cooperate fully in this project, and to release information and data which may be useful to the development of widely applicable rod mill model. It is estimated that 2-4 weeks of their time (each) would be required per year. The Consultant, Mr. C.R. Larsen, would be available for work relating to data collection, and an estimated 2-4 weeks per year of his time is required.

I. PLANNING/SAMPLING TEAM

The planning committee will consist of Dr. D. Laguitton, CANMET, as an observer, Prof. A. Laplante, Principle Investigator, the on-site engineer and Mill Superintendent, Kidd Creek, Mr. C. R. Larsen, Consultant, Prof. D. Hodouin, J. Finch, B.C. Flintoff, and A.L. Mular, Associate Investigators.

The sampling team will consist primarily of the on-site engineer, a research assistant, a summer student and a technician. Additional assistance may be required from various associate investigators and Mr. C.R. Larsen during this stage.

J. TIME SCHEDULE

An estimated time schedule to complete the tasks is as follows:

Task	Estimation of Time to Completion
1	January 1, 1983 to March 31, 1983
2	April 1, 1983 to August 31, 1983
3	September 1, 1983 to December 31, 1983
4	January 1, 1984 to April 30, 1984
5	May 1, 1983 to September 1984

Many of these tasks will overlap to some extent, so that the time estimates are approximate and should be considered as target dates for completion of the various tasks. The total time to completion is 21 months.

K. PROJECT CONTROL

Technical/Accounting control of the project will be provided by McGill University with Prof. A. Laplante as Principle Investigator. Progress reports will be submitted every two months on behalf of all participants by Prof. Laplante.

Accounting will be done by McGill University Accounting Department, based on invoices from sub-contractors and/or Associate Investigators. Invoices for progress payments will be submitted monthly.

II. PRICE PROPOSAL

This project is to be funded by CANMET, with one budget covering all expenditures by the Principle Contractor, sub-contractor and Associate Investigators.

A. BUDGET

	Year 1	Year 2
1. Salaries:		
Principle Investigator	$ 6,000	$ 6,000
Associate Investigator (4 @ $4,000)	16,000	16,000
Research Assistant (full time)	10,000	8,000
Consultant	4,000	4,000
2. Supplies/Expenses/Living accomodation on-site	8,000	6,000
3. Overhead ?	?	?
4. Computer Costs	10,000	10,000
5. Travel	5,000	5,000
6. Subcontractor		
On-site Engineer (part time)	10,000	5,000
Summer student (4½ months)	8,000	-
Technician (5½ months)	10,000	3,000
Overhead ?		
TOTAL	$87,000	$63,000

Project Total $150,000

Note: If additional sampling is required as part of task 4, there may be additional costs incurred (max. $5,000).

B. Cash Flow Chart

TO BE
ESTABLISHED
FOLLOWING
DISCUSSIONS
WITH
KIDD CREEK

C. BENEFITS

1. Technological: A production rod mill model, based on dynamic concepts is not available. SPOC will be first with this new technology.

2. To Kidd Creek: Kidd Creek stands to benefit economically, because measureable losses in production might be avoided.

3. Industry: A successful rod mill model will permit other processing plants to evaluate the influence of cyclone underflow on capacity. Potential benefits are substantial.

4. Government: CANMET benefits from credit in their monetary contribution and for directing the SPOC program. Government benefits through increased productivity by disseminating improved technology.

It is difficult to assess, quantitatively, the economic benefits. This is possible to do at the end of the projects.

APPENDIX XI

Evaluation of the Rod Mill Modelling Study at Kidd Creek Mines

Evaluation of the Rod Mill Modelling Study at Kidd Creek Mines Ltd.

Prepared by A.R. Laplante

Submitted to:
CANMET (SPOC PROJECT)
553 Booth St.
Ottawa, Ontario

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INTRODUCTION

The present report is an evaluation of the Kidd Creek site for the application described in the terms of reference, namely 'a successful application of off-line optimization methodology'. It is specified that 'the existing problem must be well within the range of the methodology'. These terms of reference are unequivocal, and will form the basis of our evaluation.

Point 1. Statement of the Problem

The problem was originally stated in a document I received from Mr. R. Greer, dated August 16, 1982. The high circulating loads in the primary grinding circuit necessitate decreasing rod mill feed rate, resulting in up to about 2.5% of total throughput loss. It is felt that the partial recycling of cyclone u/f to the rod mill should alleviate the problem. Previous questions had been raised by O. Matwijenko, as to the effect of rod mill feed size on circuit throughput and feed assay vs. grindability (letter to Dr. Laguitton, May 14, 1982).

Clearly the main interest is centered on the rod mill, with emphasis on the effect of feed size, hardness, and the effect of 'fines' recycling.

Point 2. Rod Mill Models: Statement of the Art

Grinding kinetics in rod mills are more complex than in crushers or ball mills. Rods are kept apart by coarser particles at the feed end, resulting in classification and preferential grinding. Thus grinding kinetics vary axially throughout the mill, and lumped parameter models are inappropriate. Even existing distributed parameter models are inadequate, as the effects of feed size, hardness and rate on internal classification and grinding are not quantitatively known. These two phenomena are also very difficult to characterize separately,

as they both have the same cause (rod spreading) and effect (coarser particles being ground very effectively). As a result, most continuous rod mill models use a compromise between lumped and distributed parameter models, that is, simple cycle-by-cycle grinding. The limits of this model are severe, and it is felt that a better one must be built.

The new model* would most likely treat the rod mill as made of many longitudinal segments, in which grinding and classification would be described by a lumped parameter model. Extensive laboratory work would be necessary in order to describe how the parameters change axially. Batch mill modelling would isolate the effect of particle size on the breakage. Continuous milling would yield the effect of particle size both on breakage and classification. The effect of classification could be inferred comparing batch to continuous results. The model would then be plant tested.

Point 3. SPOC Methodology to Solve Kidd Creek's Problem

The existing rod mill model can describe the effect of feed size, hardness or rate only semiquantitatively. The effect of fines recycle (e.g., from cyclone u/f) cannot effectively be modelled. Thus, it is felt that existing SPOC methodology cannot successfully be used to solve Kidd Creek's problem as

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*This modelling approach has not been discussed by the sub-committee. It is presented only as a starting point.

described. Another site must be selected, in accordance with the terms of reference.

Point 4. Kidd Creek as the Site for the Testing of a New Rod Mill Model

The committee has retained Kidd Creek as the best site for testing a new rod mill model. The criteria used are those presented in the terms of reference:

Management. Kidd Creek management has shown 'non-ambiguous support' (Appendix 1).

Economics. The 'cost to benefit' ratio criterion is not strictly applicable to model development. Nevertheless, the potential circuit improvement means that Kidd Creek is willing to shoulder part of the costs. Testing the effect of fines recycle will make the rod mill model more versatile, and is justified by the potential economic benefits.

Geographical. Kidd Creek has excellent accessibility, is centrally located, and enjoys a high visibility in the field.

Problem. Again this criterion is not entirely relevant to model development project. Nevertheless, it is felt that because the questions raised by Kidd Creek cover most of the important rod mill variables, excellent support will be given to the entire project.

Ore. The Kidd Creek ore has roughly a 50:50 sulphides/silicates ratio, which is typical of many Canadian ores. Its grade fluctuates sufficiently from month to month to test the effect of ore hardness in the model.

Resources. Kidd Creek has sufficient staff and mill instrumentation resources to complete the plant work successfully. Preliminary talks indicate a willingness to commit these resources to the project.

Description of the Project. A sample research proposal has been prepared by W.A. Dutton, and is available for discussion.

CONCLUSION

The Kidd Creek problem as presently defined cannot be solved with existing SPOC methodology. However, it is well in the scope of the model development/improvement task as defined by the sub-committee. We recommend that Kidd Creek be selected as 'best site' for a rod mill model study, as part of SPOC phase 3.

Kidd Creek Mines Ltd.
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Metallurgical Site (705) 235-8121

September 30, 1982

Mr. A. Laplante
McGill University
Frank Dawson Adams Building
3450 University Street
Montreal, PQ H3A 2A7

Dear Mr. Laplante:

I am pleased to inform you that Kidd Creek Mines is willing to be put forth as a candidate for participation in Phase 3 of the SPOC program. We are looking forward to negotiating the terms of our participation in this project as previously outlined in your letter of September 3, 1982.

Yours sincerely,

G. W. Moore
Superintendent
Concentrator

GWM/cb

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